# Electrical Level 4

Medium-Voltage Terminations/Splices 26411-14

# Objectives

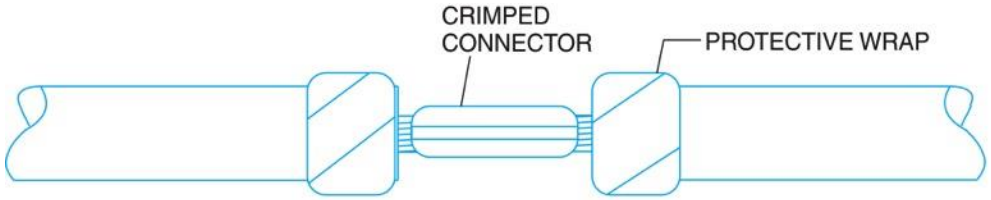
**When trainees have completed this lesson, they should be able to do the following:**

1. Recognize the factors related to motor reliability and life span.
2. Measure motor winding insulation resistance and compensate for temperature.
3. Identify motors needing replacement.

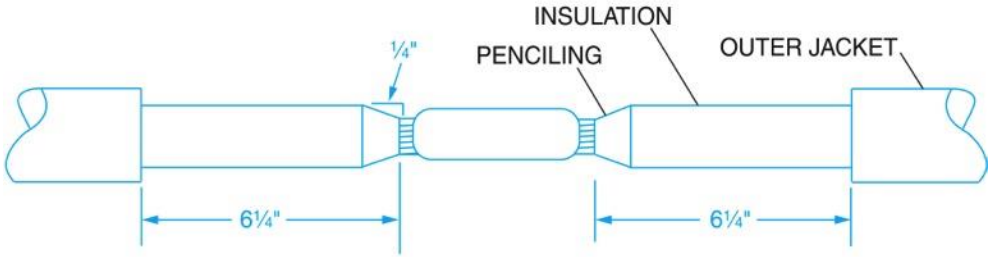
# Performance Task

Prepare a cable and complete a splice or stress cone.

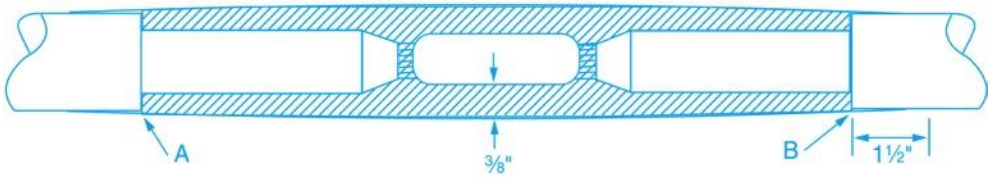
# Introduction




**A.** APPLY A PROTECTIVE WRAP OF TAPE TO THE JACKET ENDS TO PROTECT THE JACKET AND INSULATION WHILE CLEANING AND SECURING THE CONNECTOR.




**B.** REMOVE ADDITIONAL JACKET AND INSULATION BY AN AMOUNT EQUAL TO 25 TIMES THE THICKNESS OF THE OVERALL INSULATION.




**C.** INSULATE AND TAPE THE SPLICE.

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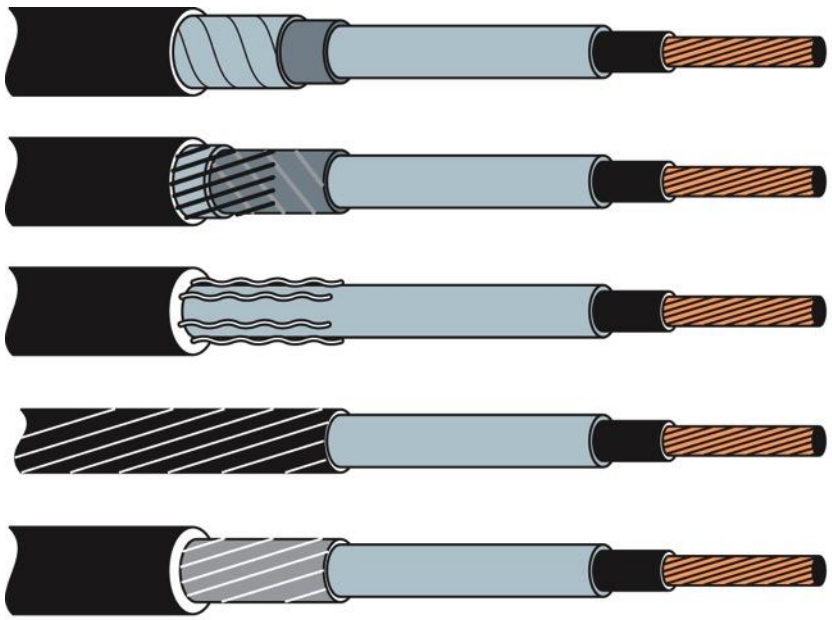
# Medium-Voltage Power Cable



RIBBON TAPE SHIELDED

DRAIN WIRE SHIELDED

CABLE UNISHIELD ®

CONCENTRIC NEUTRAL (CN)

JACKETED CONCENTRIC NEUTRAL (JCN)

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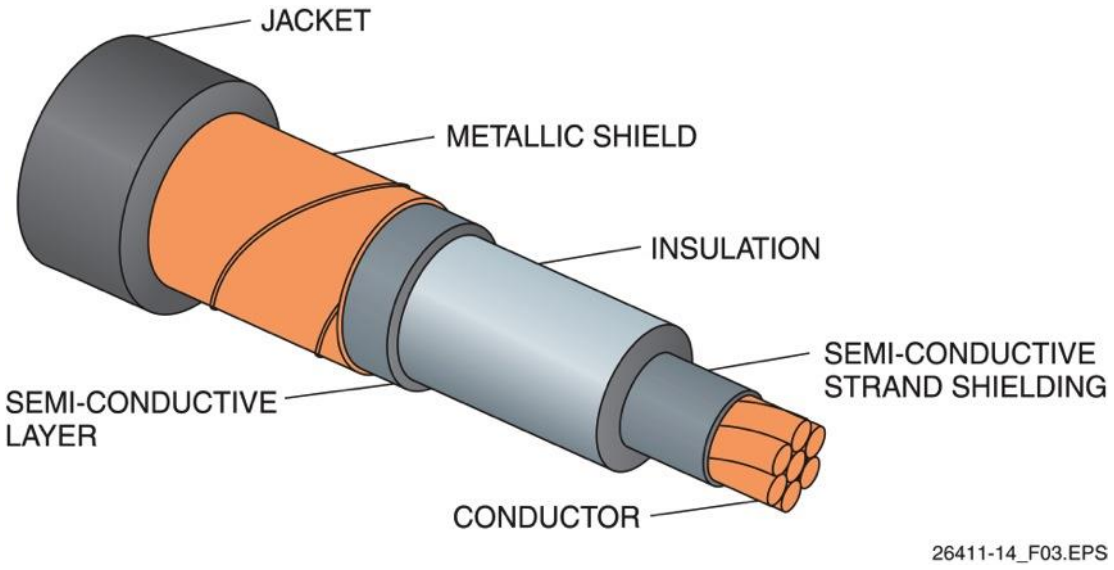
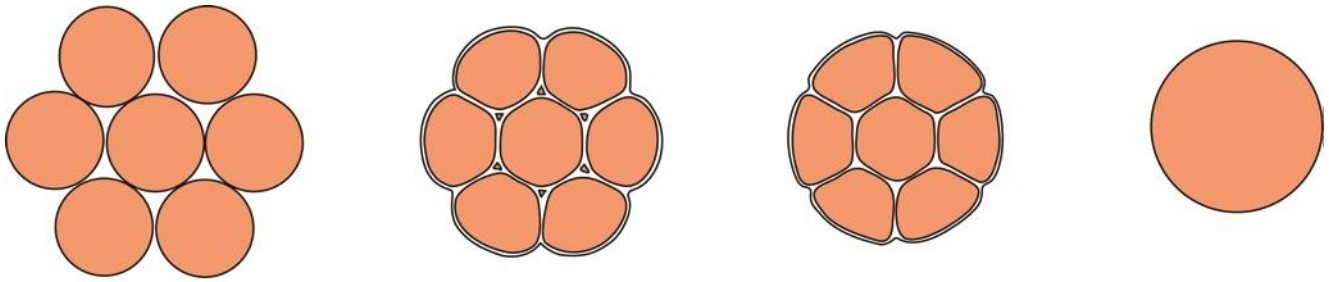
# Basic Components of Medium-Voltage Cable

Each cable component is essential to proper system performance and must be considered when making a splice or termination.



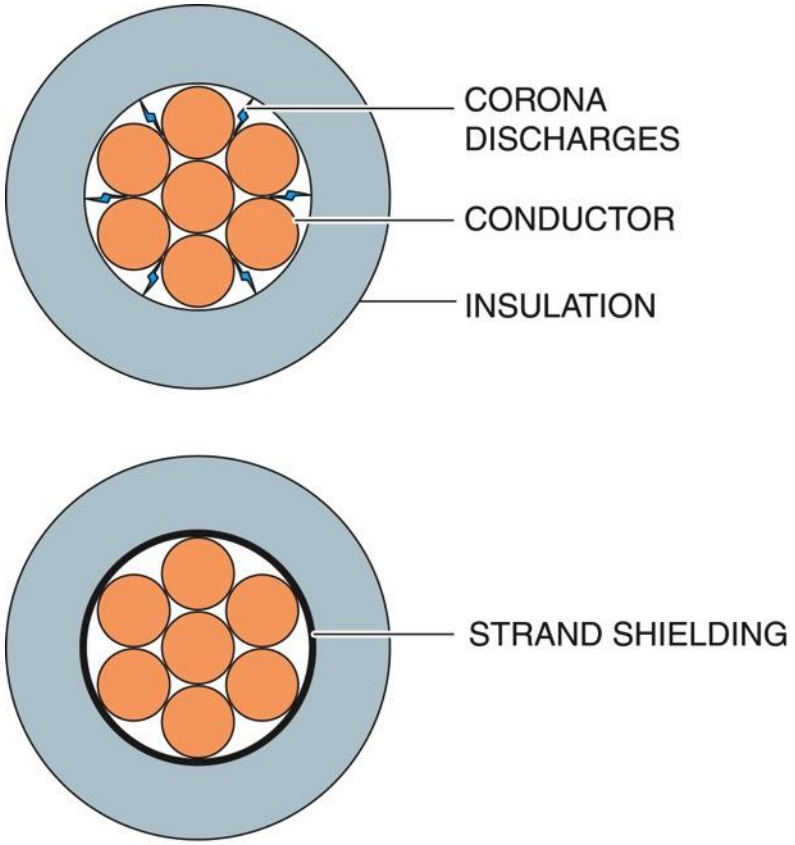
# Basic Cable Configurations

- Concentric stranding is not used in shielded power cables because the extruded strand shielding is difficult to remove when making field connections.
- Compressed stranding is reduced to 97% of concentric conductor diameters. The extruded strand shielding does not penetrate and is easily removable.
- Compact stranding is reduced to 90% of concentric conductor diameters and should be sized down for molded rubber devices.
- Solid wire is not used in industrial shielded power cable.



# Strand Shielding

- Strand shielding is the semi-conductive (semi-con) layer between the conductor and the insulation.
- Strand shielding fills the air voids between conductors and eliminates the insulation-degrading corona discharges caused by the ionization of air.

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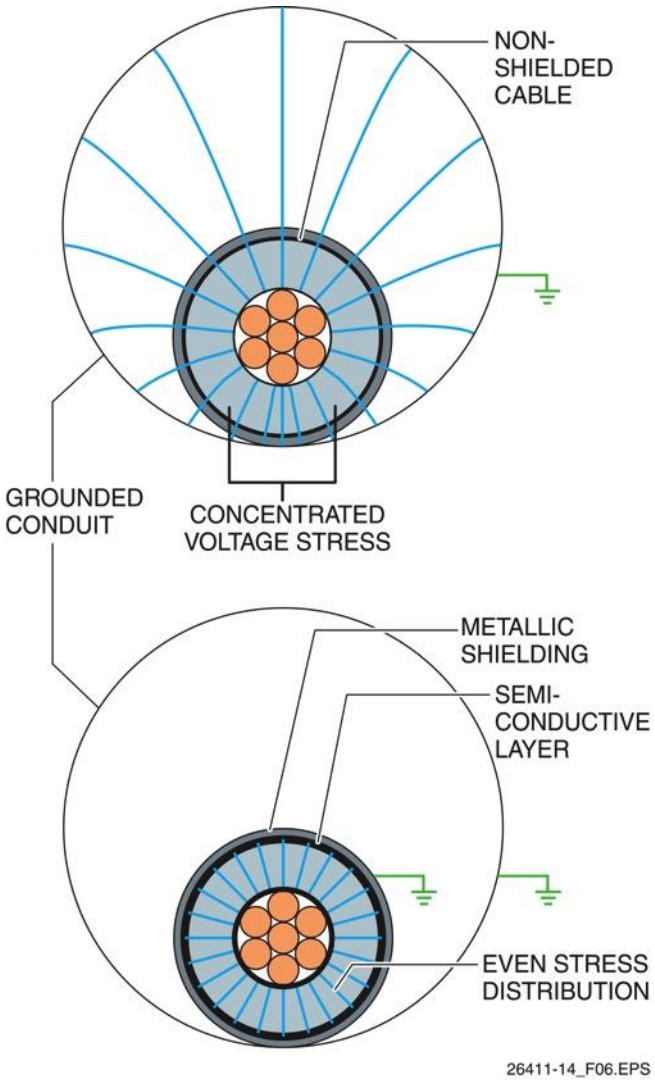
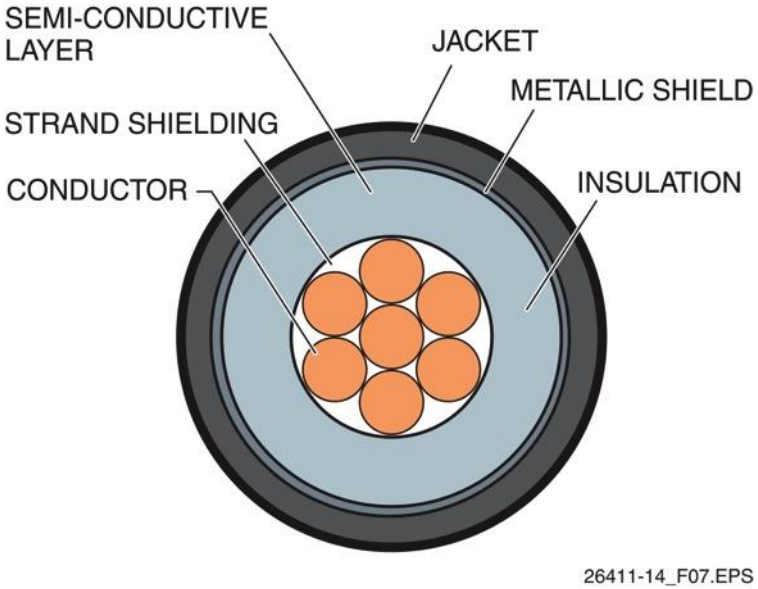



# Insulation Shield System

- The outer shielding contains a semi-conductive layer under a metallic layer.
- The shield system provides even stress distribution and protects the cable from induced voltages and radio interference. It also reduces shock hazard and provides a ground path for leakage and fault currents.

# Jacket and Insulation




- The outer jacket provides mechanical protection and a moisture barrier.
- Typical materials used for cable jackets include PVC, neoprene, and lead. Industrial three-conductor cables frequently include an armored sheath.

# Splicing I

- Splices should be avoided whenever possible, but may be required due to cable damage or failure, insufficient length or room for the proper bending radius, excessive twisting, or taps.
- The basic steps in a cable splice include preparing the cable, joining the conductors with connectors, reinsulating, reshielding, and rejacketing.

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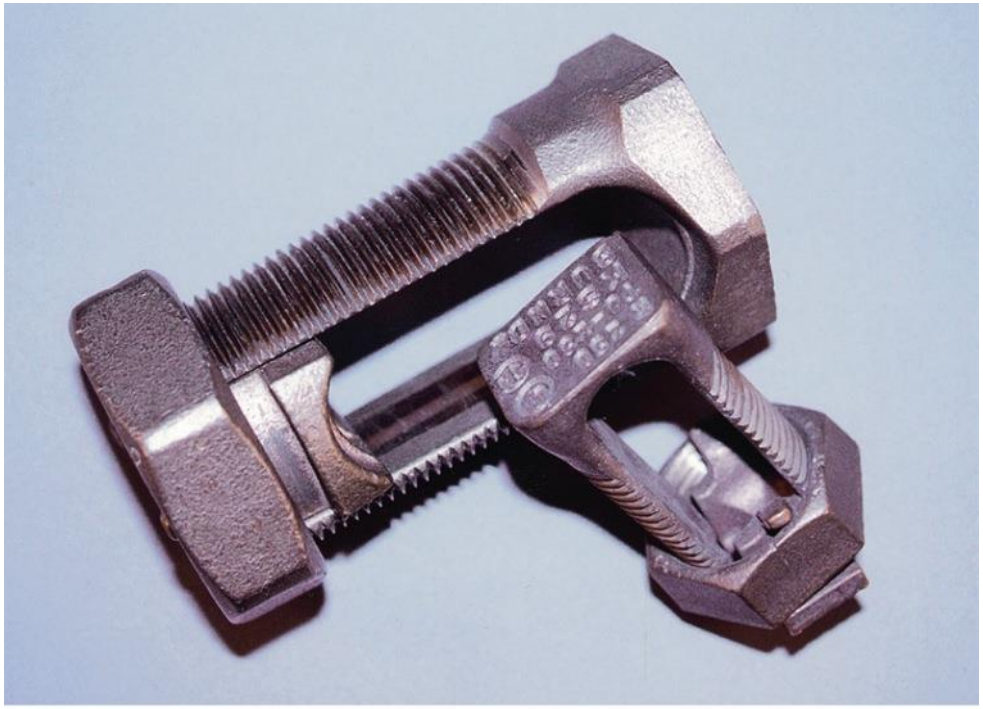
# Think About It: Mechanical Connectors

Could you use the connectors shown here to make a high-voltage connection?



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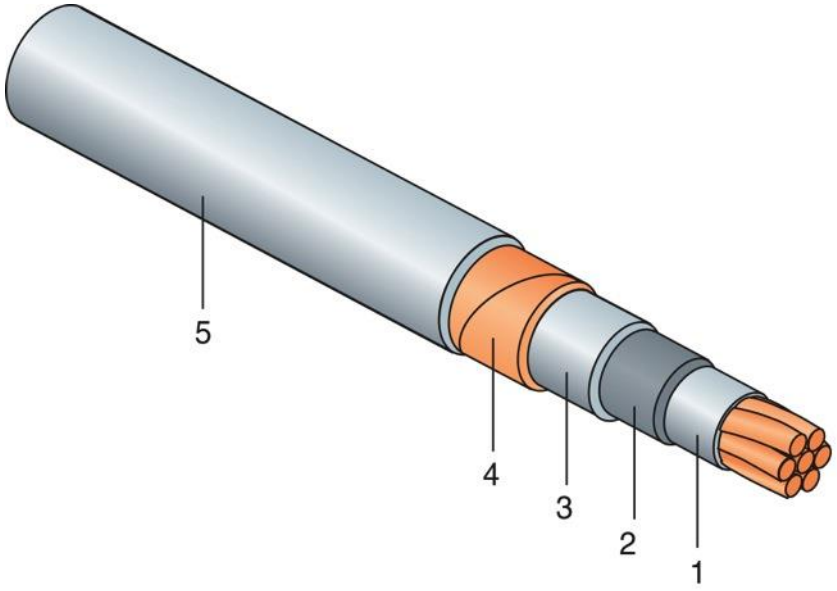
# High-Voltage Cable Construction




1. STRAND SHIELDING – Semi-conductive material
2. PRIMARY INSULATION – Ethylene propylene or cross-linked polyethylene
3. INSULATION SHIELD – Semi-conductive material
4. CABLE METALLIC SHIELDING – Metallic or wire
5. JACKET – PVC, neoprene, polyethylene

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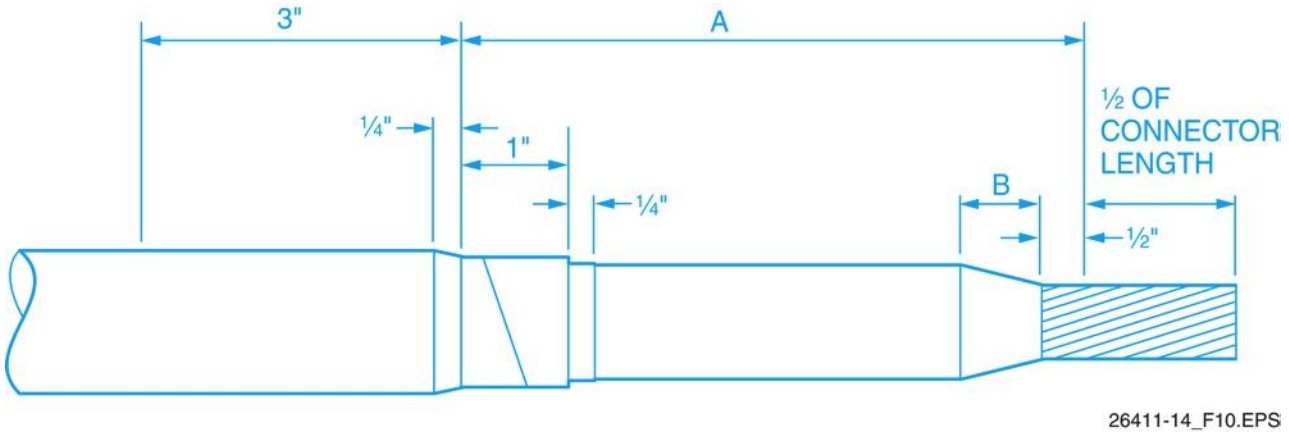
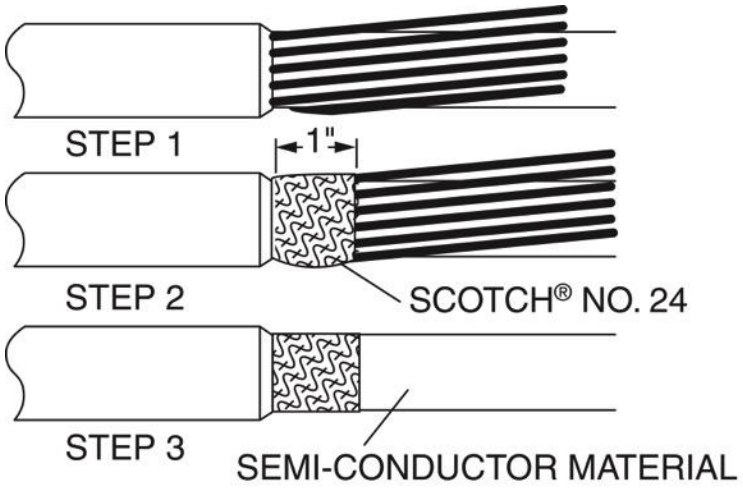
# Recommended Cable Preparation Procedures for an Inline Splice




- When preparing cable for a splice, train the cable and cut it carefully so the end is square.
- Remove the jacket and nonmetallic filler tape, cable metallic shielding, semi-conductive material, and cable insulation to the dimensions indicated. Take care not to nick the conductor.

# Wire Shield Procedure

Follow the procedure shown here if using shielded wire cable.




1. Remove cable jacket per previous instructions. Be careful not to cut any of the wires.
2. Wrap two unstretched layers of Scotch® electrical shielding tape 24 over shield wires for 1" beyond cable jacket. Tack in place with solder.
3. Cut shielding wires off flush with leading edge of tape.

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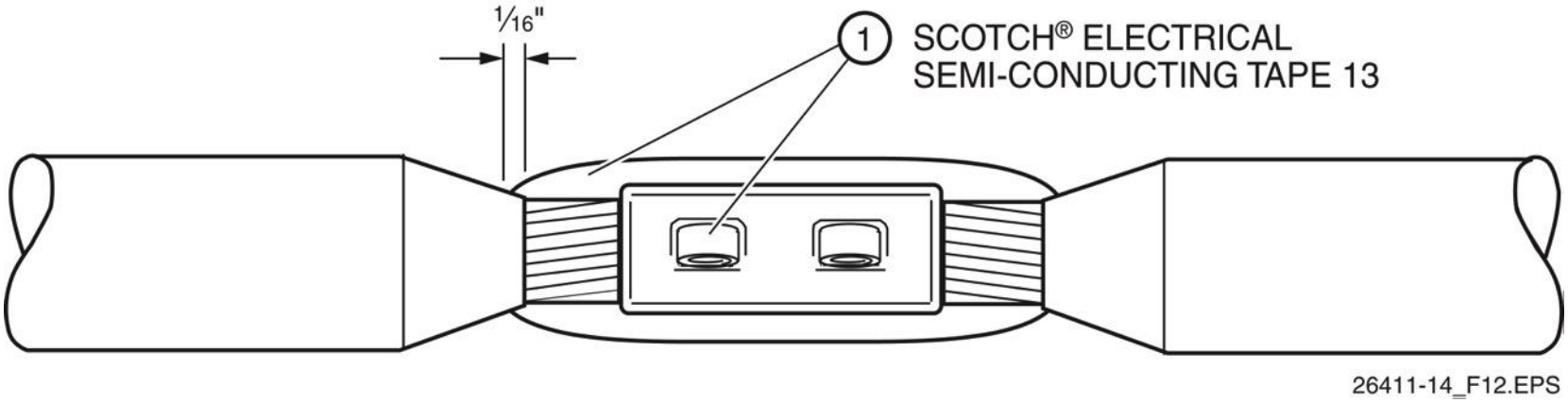
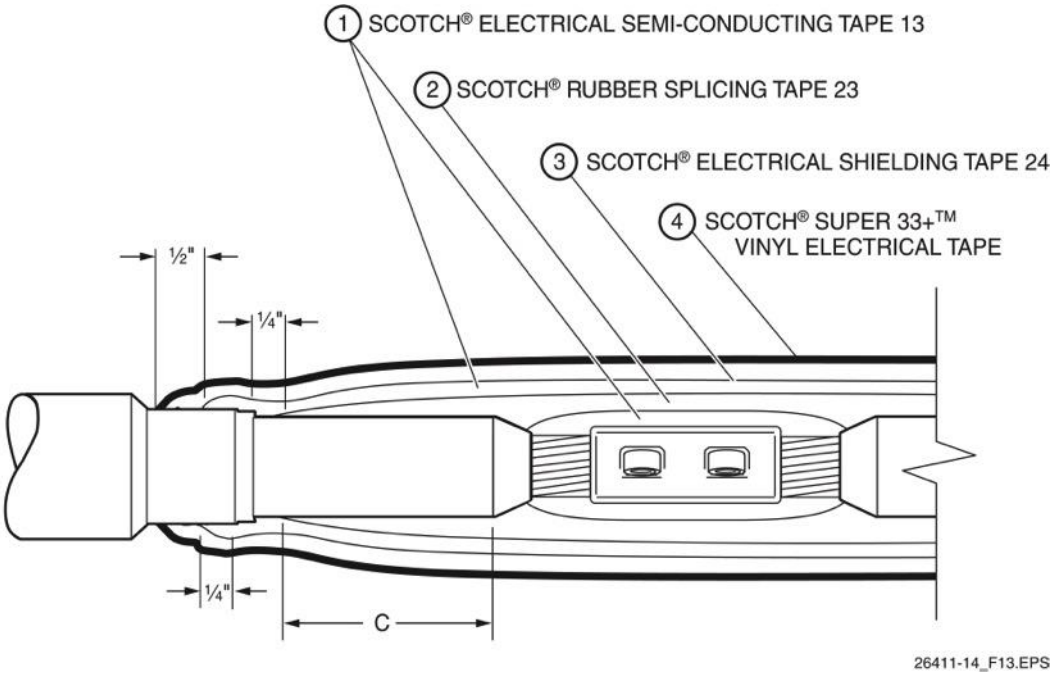
# Connecting Conductors

- Join the cables using an appropriate connector. Use a crimp connector to join thermoplastic-insulated cables.
- Fill the conductor indents with semi-conductive tape, as shown here.

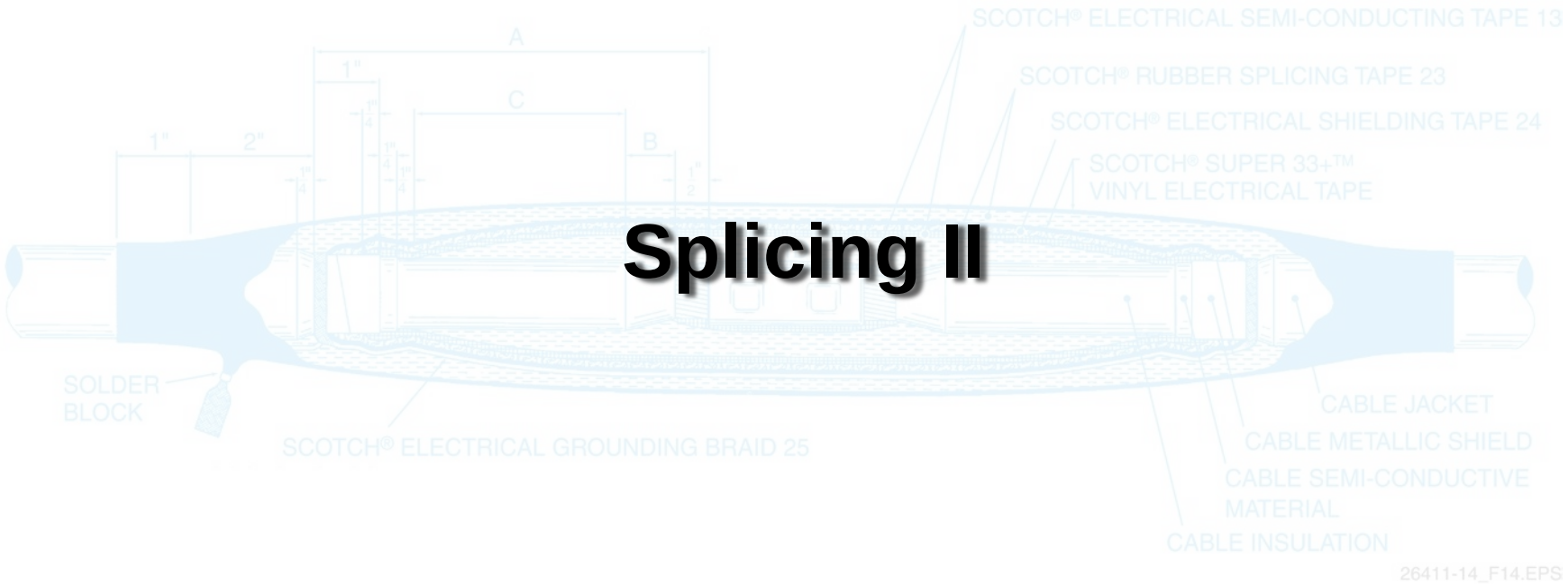


# Applying Primary Insulation



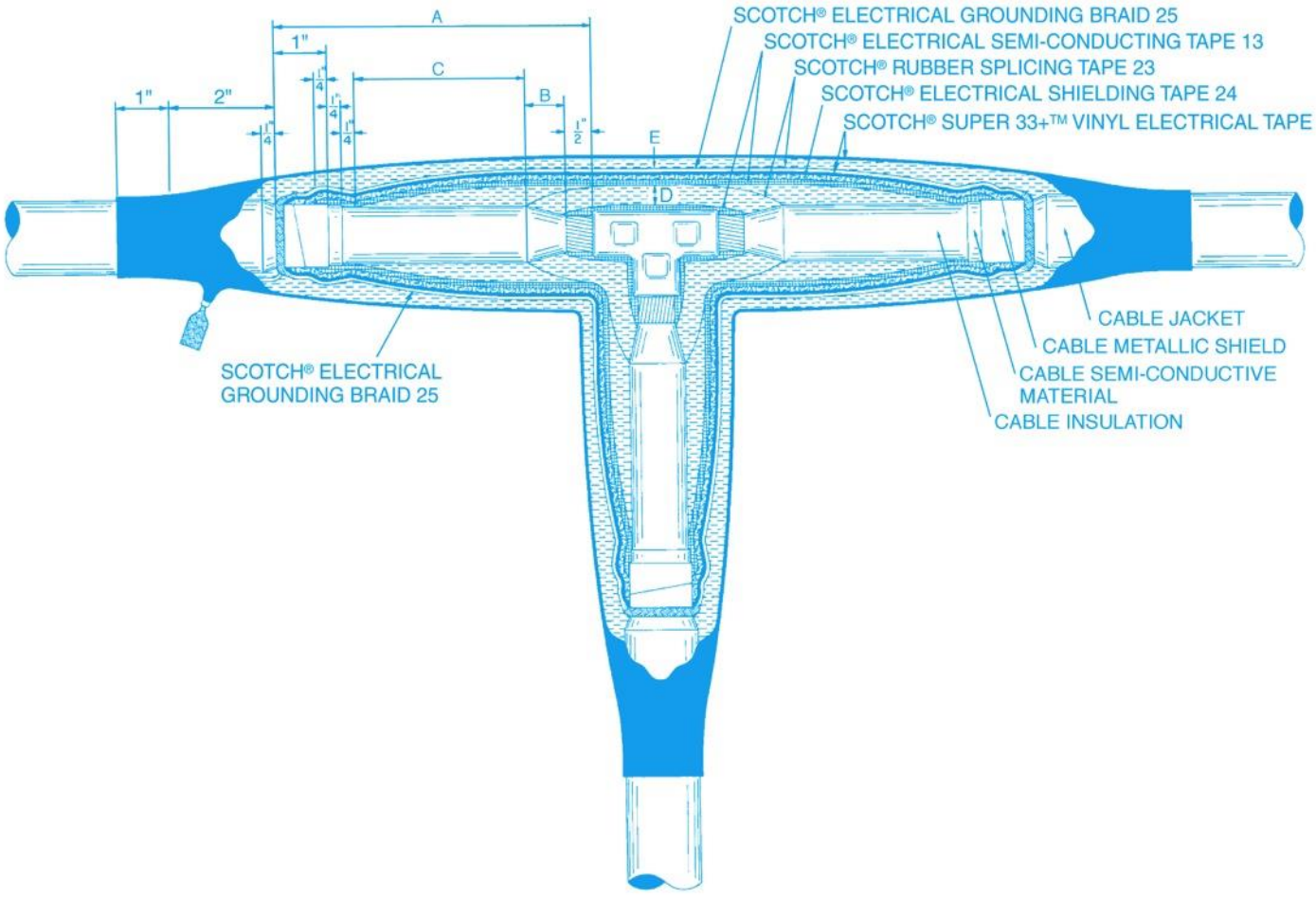

- Apply medium-voltage splicing tape to replace the primary conductor insulation.
- Various types and layers of tape may be required. Follow the manufacturer's instructions for the product in use.

# Next Session...




## Splicing II

# Splicing II

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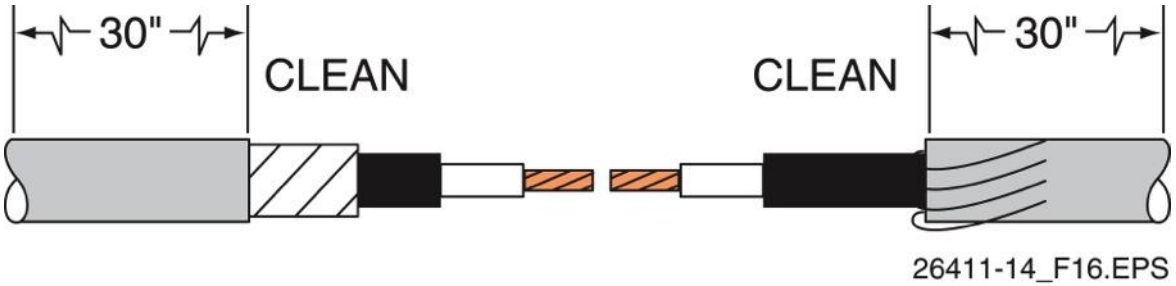
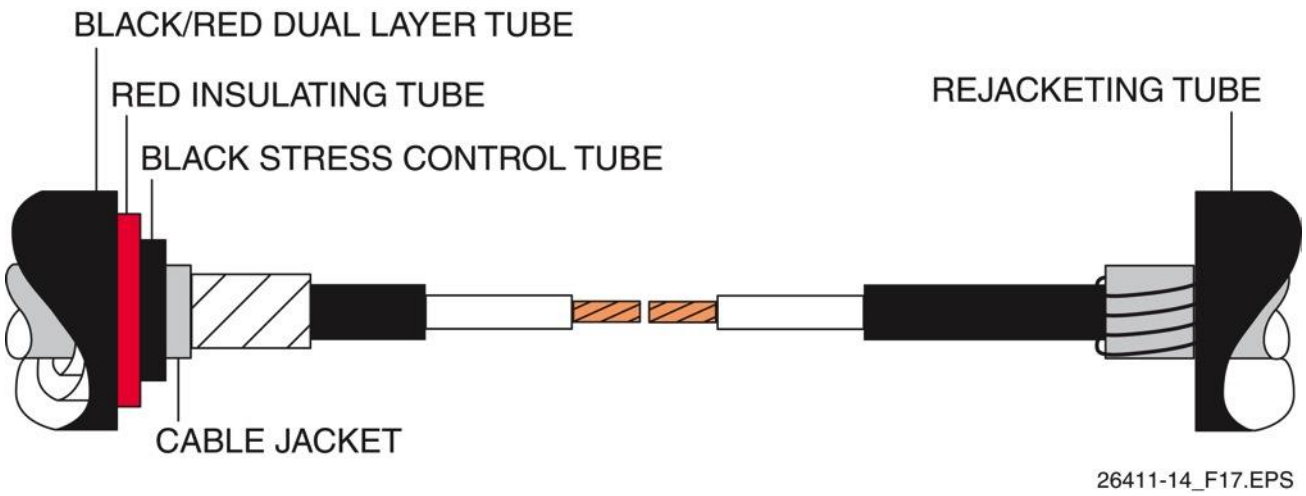
# Preparing the Cables



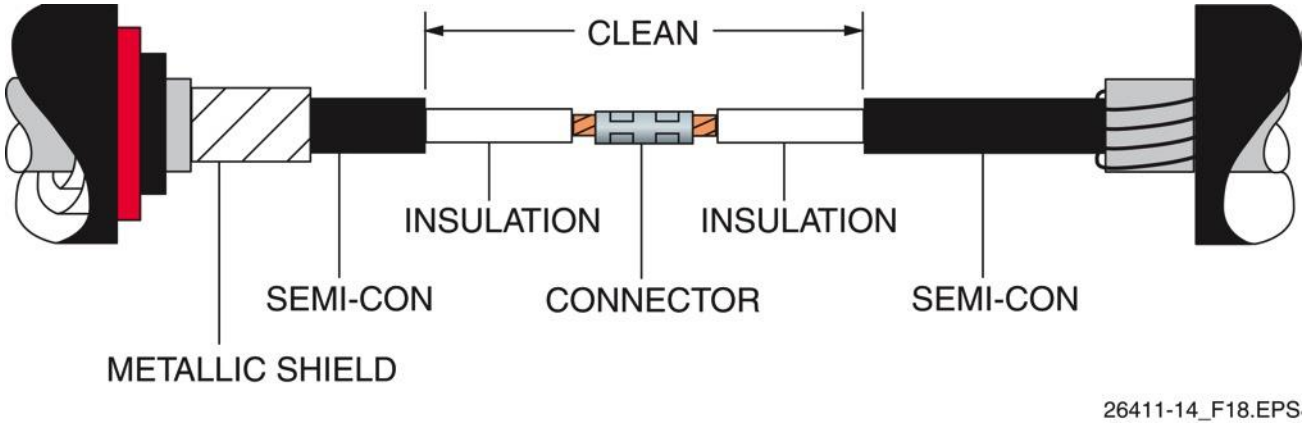

- Manufactured termination/splice kits include cable preparation materials, semi-conductor, stress control, jacketing, sealing, and grounding. Both heat-shrink and cold-shrink kits are available.
- To use a quick inline splicing kit, select the correct kit for the cable diameter, cut back the cable as specified, and clean the cable jacket for the length of the tubes.

# Placing the Nested Tubes on the Cable



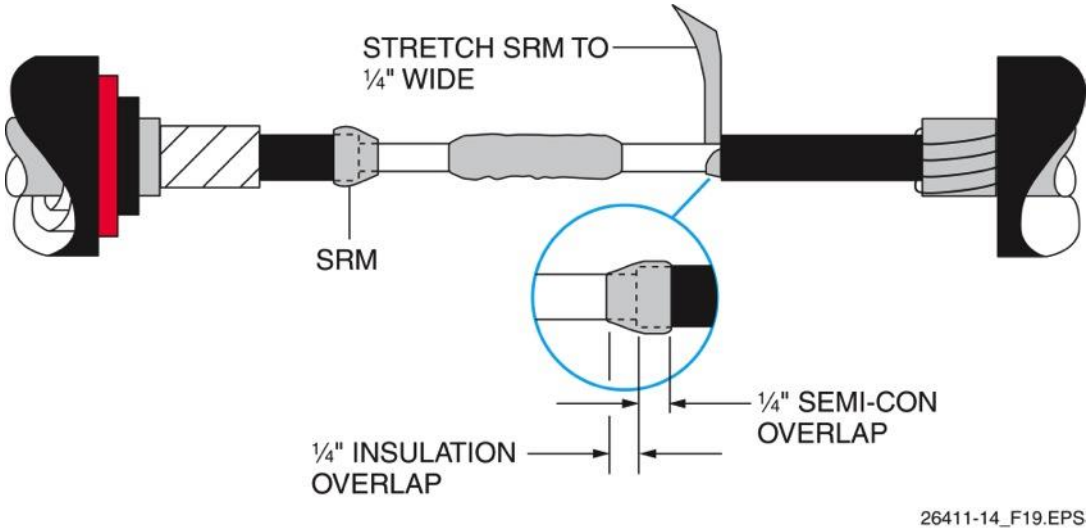

- Place the nested tubes and the rejacketing tube over the cables as shown.
- Protect the tube from the sharp ends of the conductor as they are placed over the cable.

# Installing the Connector



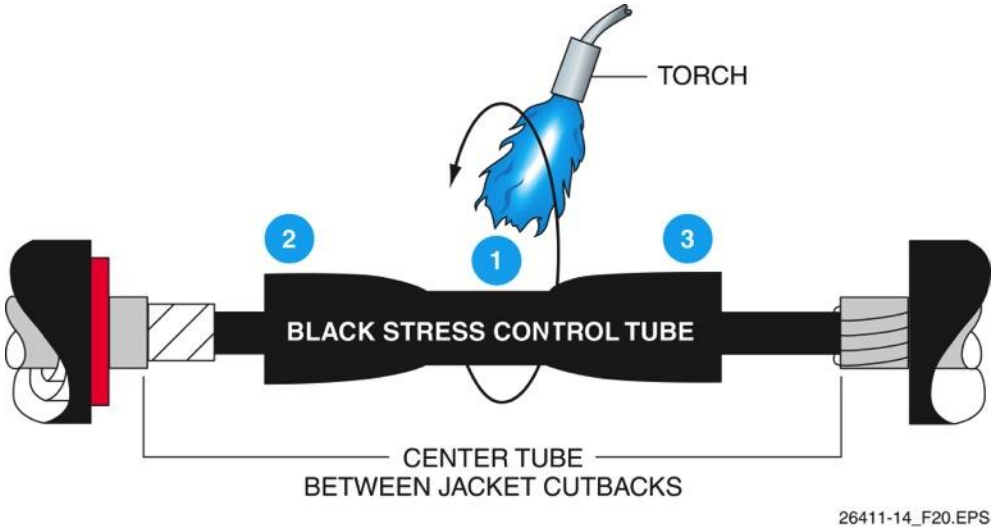

- Install the connector.
- Wipe the insulation down using an oil-free solvent. Note that some solvents do not evaporate quickly and must be removed using a clean, lint-free cloth.

# Installing the Stress Relief Material




- Tightly wrap the exposed conductor with the stress relief material (SRM), making sure to fill all gaps and low spots around the connector. Also install SRM over the semi-con cutback areas.
- If the connector diameter is larger than the insulation diameter, apply two overlapped layers of SRM along the length of the entire connector.

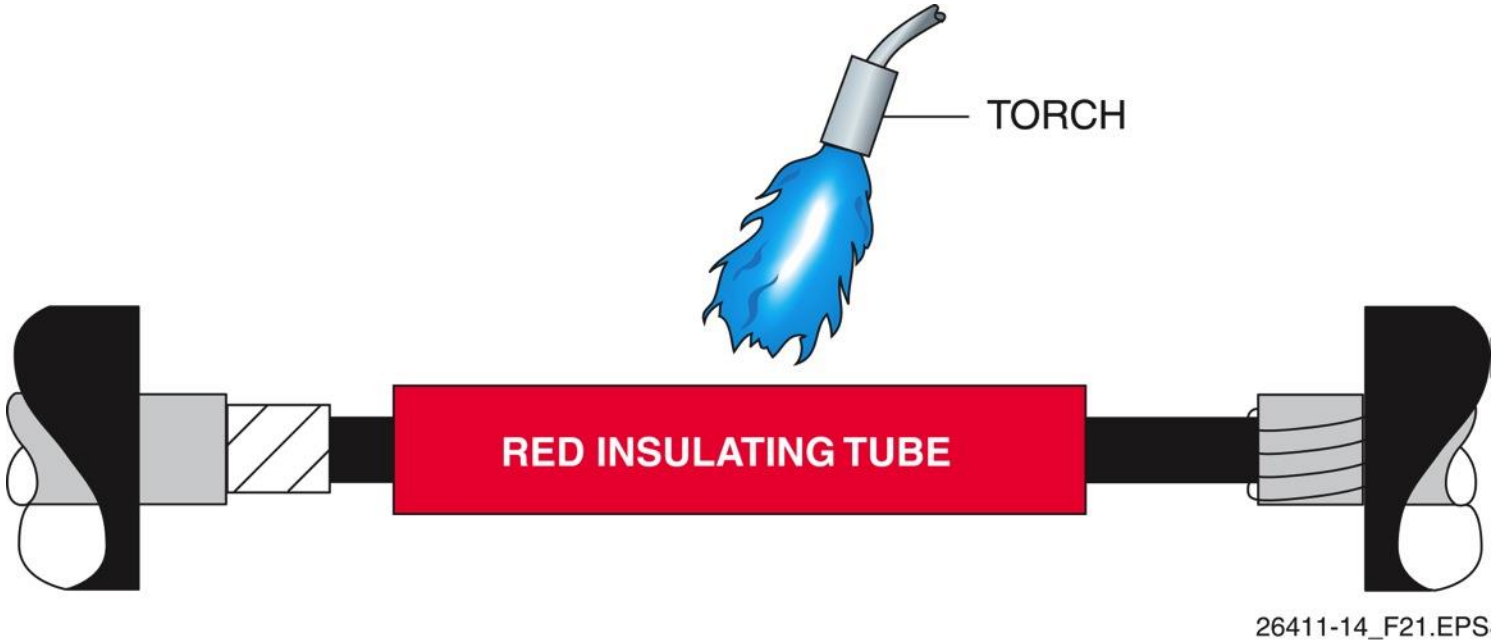
# Shrinking the Stress Control Tube




- Center the stress control tube over the splice and shrink it into place.
- Follow all safety precautions for torch use. Use a smooth brushing motion and keep the flame moving to avoid damage. Unless otherwise indicated, start at the center of the tube and move outward.

# Shrinking the Insulating Tube

Position the insulating tube over the stress control tube and shrink it into place.

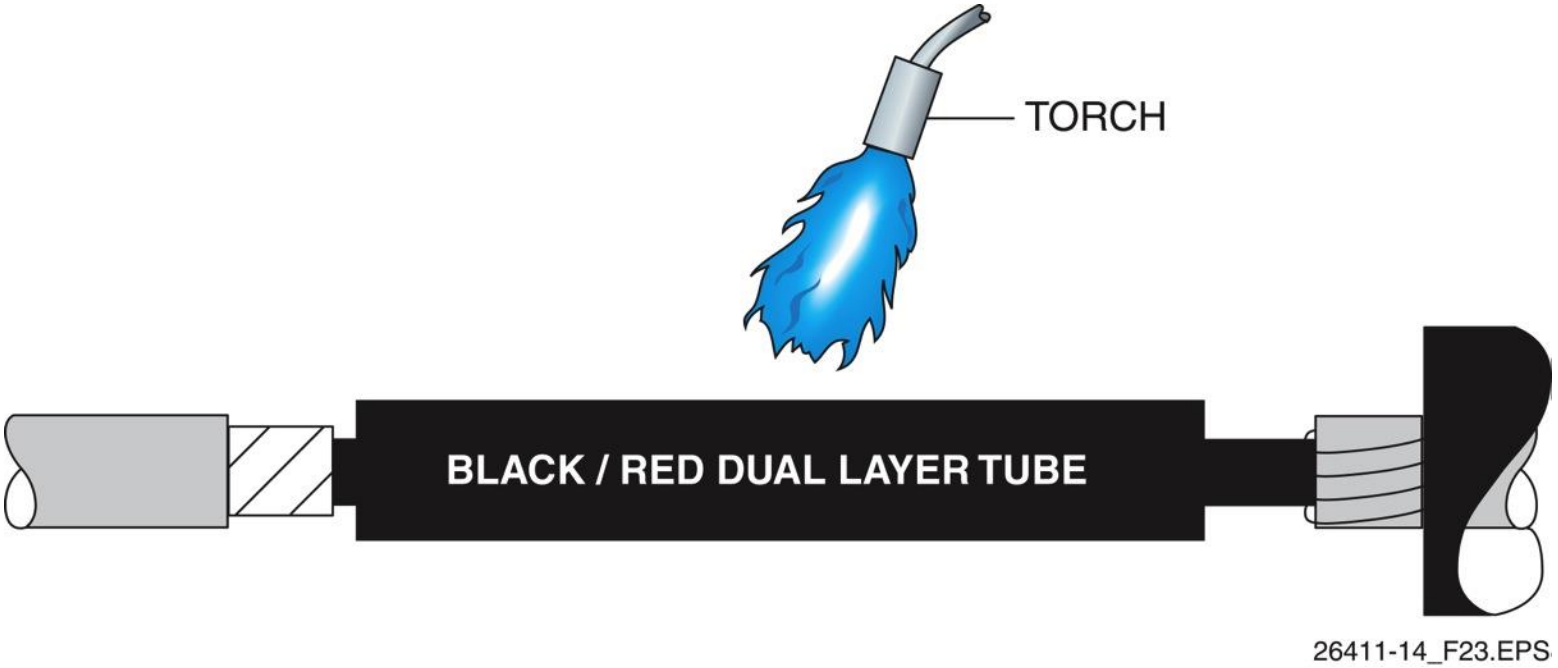


# Applying Sealant

- Apply sealant to the tube ends to provide a positive environmental seal.
- Build the sealant to the level of the insulating tube.

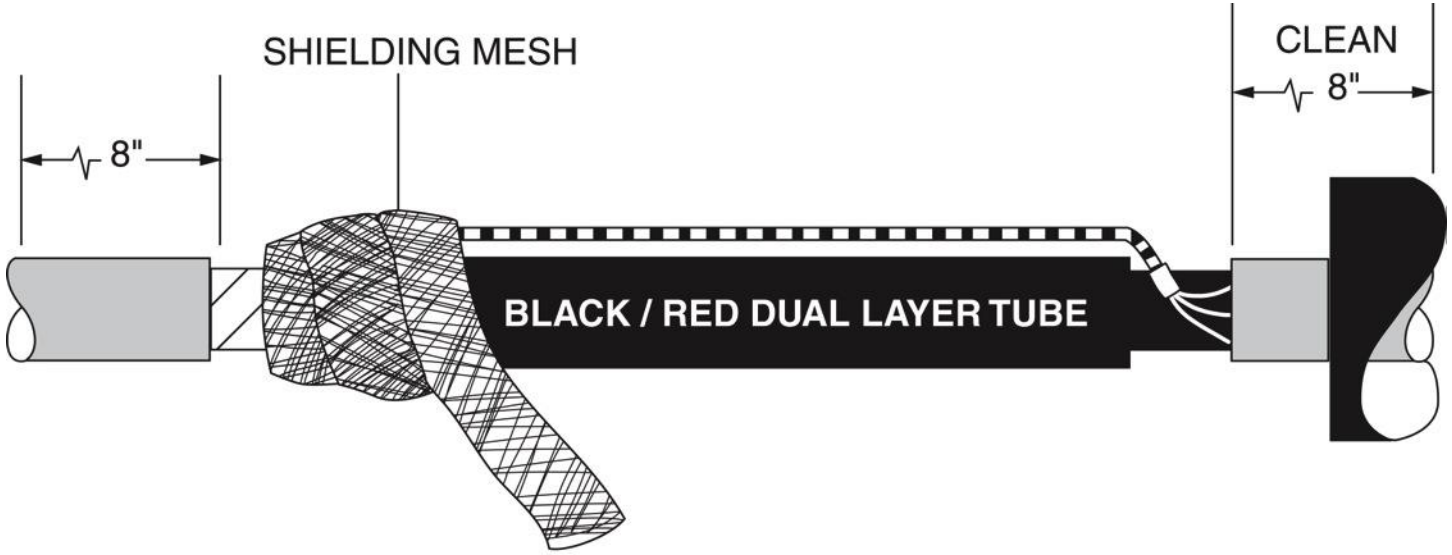
# Shrinking the Insulating/Conductive Tube

Position the insulating/conductive tube over the insulating tube and seal the ends before shrinking into place.



# Installing Metallic Shielding Mesh

- Install metallic shielding mesh using manufacturer-supplied constant-tension clamps for metallic tape shielding.
- Use crimp connectors for wire shielding.

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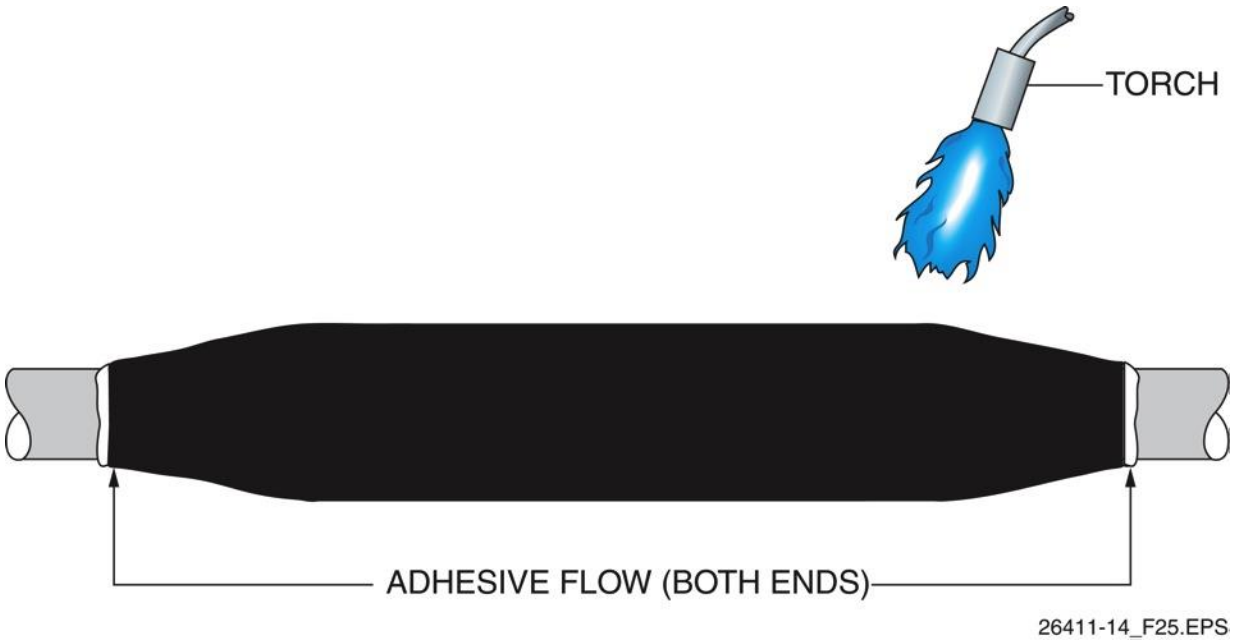
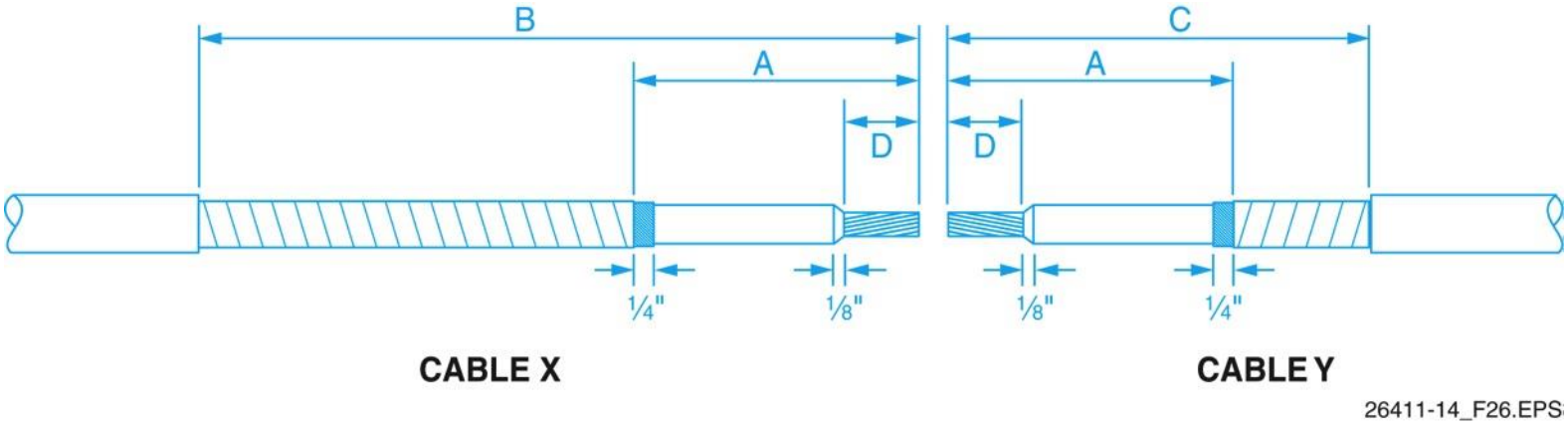
# Shrinking the Rejacketing Tube and Checking for Adhesive Flow

- Position the rejacketing tube and shrink it into place.
- Check the ends for correct adhesive flow.



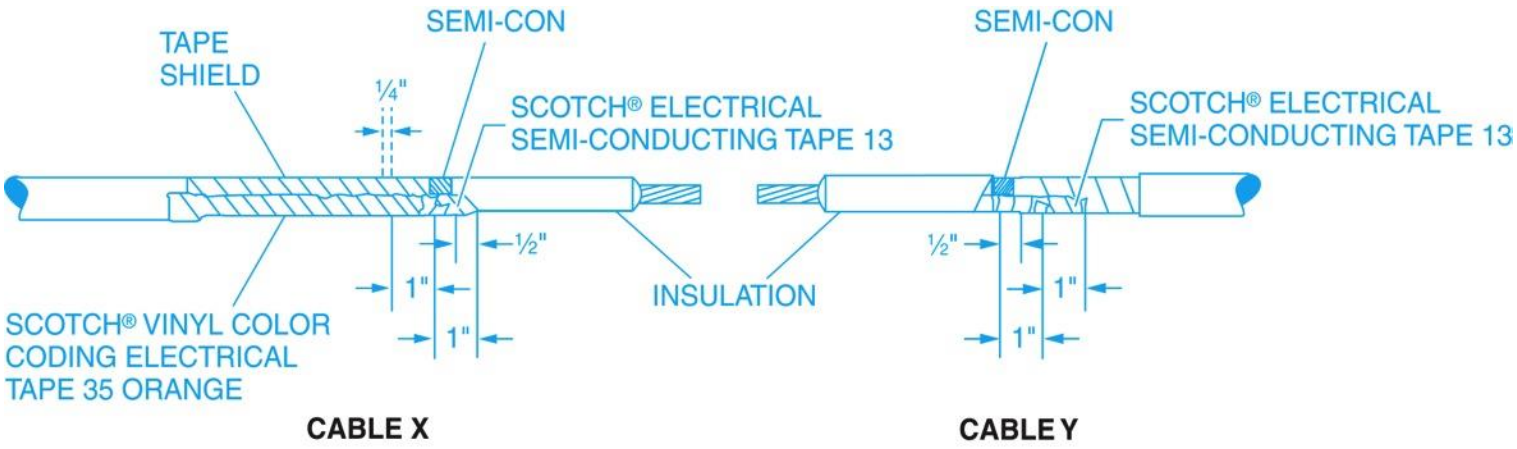
# Cable Preparation Details

- To use a cold-shrink quick inline splicing kit, clean the cable jacket, then remove the specified lengths of metallic shielding, cable semi-conductive material, and insulation.
- Clean the exposed insulation using the cleaning pads in the kit. Do not use solvent or abrasive on the semi-con layer.



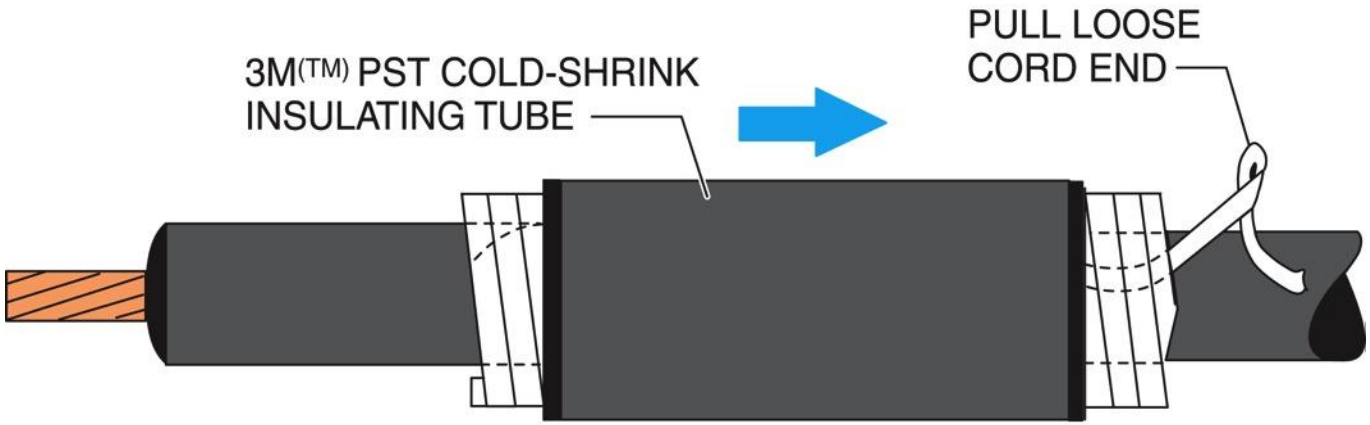
# Components of a Ribbon Shielding Cable Splice

- Apply two layers of semi-conductive tape as shown. Leave a smooth leading edge and tape back to the starting position.
- Apply a layer of orange vinyl tape adhesive side up on one of the cables over the metallic shield.



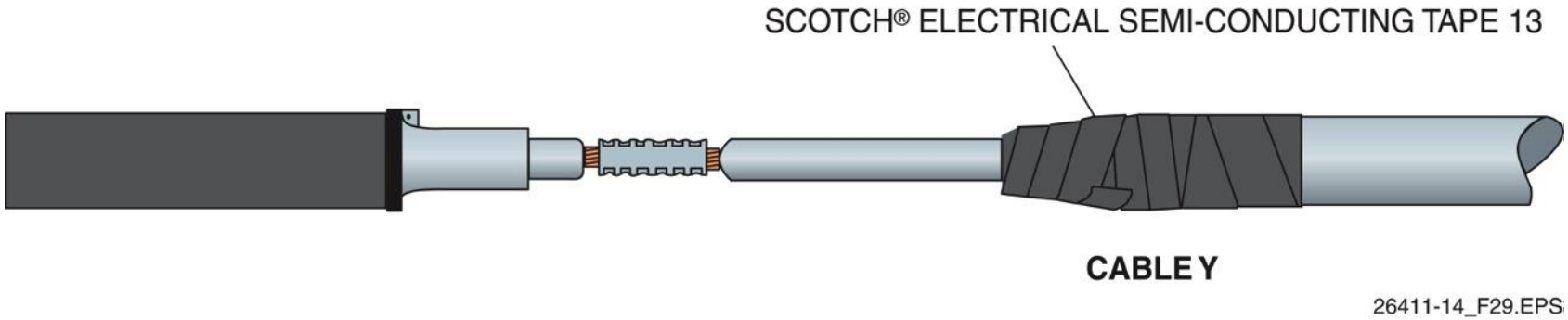
# Installing PST Cold-Shrink Insulator

- Slide the longer PST insulator over the jacket with the orange tape and the shorter PST onto the other jacket.
- Lubricate the exposed insulation with silicone grease.



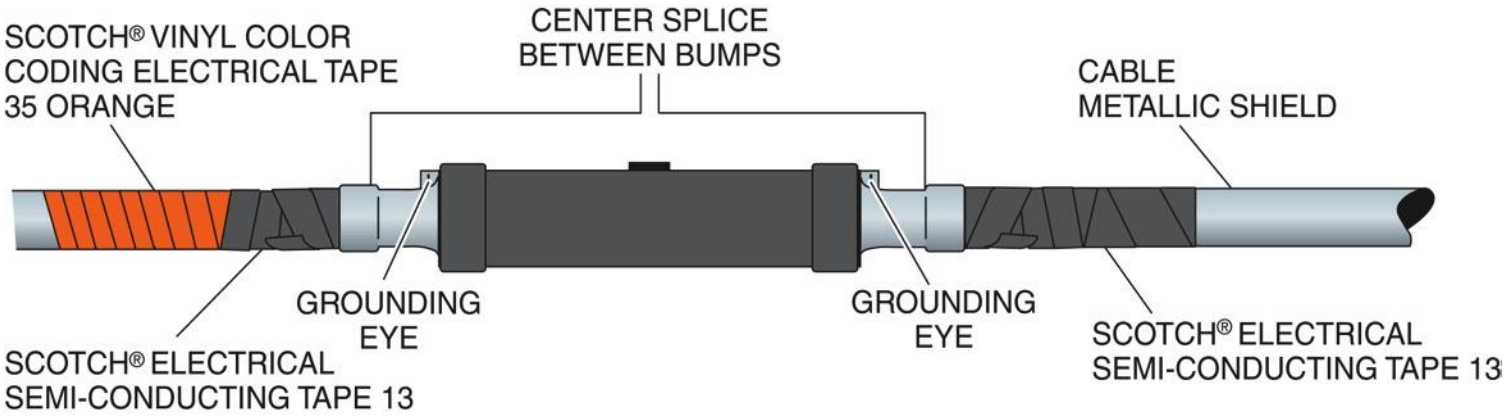
# Wrapping No. 13 Tape onto the Cable

- Lubricate the splice bore with silicone grease and install it onto the orange-taped cable, leaving the conductor exposed for the connector.
- Install the crimped connector.



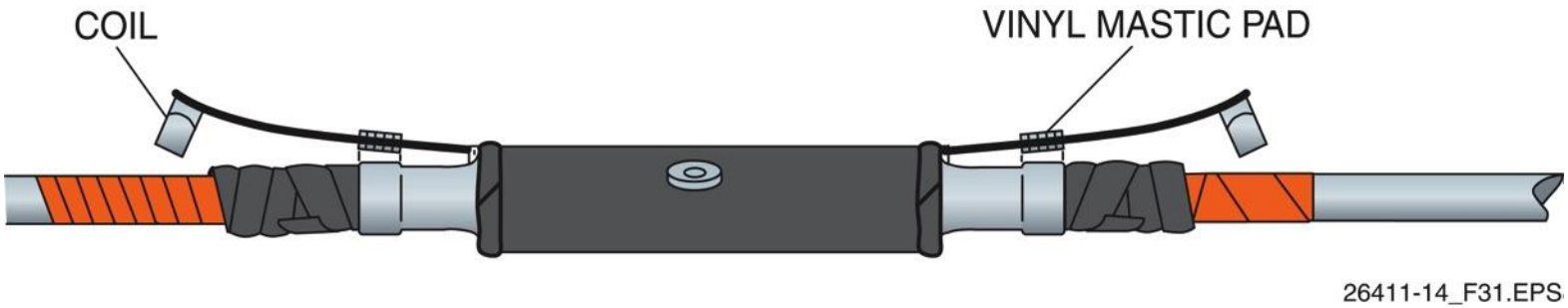
# Use Bumps Formed on Splice Ends as Guides for Centering

- Slide the splice body into its final position over the connector, using the bumps formed on the splice ends as guides for centering.
- Wipe off any remaining silicone grease.



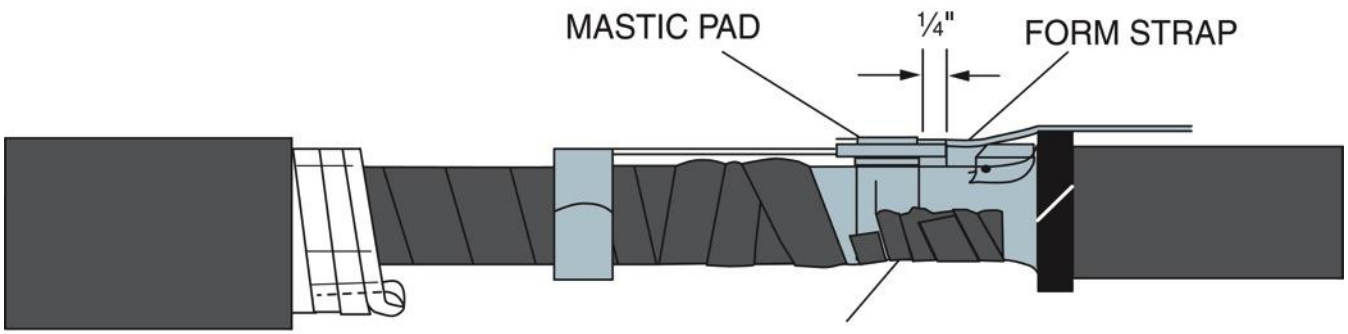
# Wrap Vinyl Tape at Each End of the Splice Body

- The shield continuity assembly must be installed after reinsulating a splice.
- Position the assembly over the splice and hold it in place using pieces of vinyl tape at each end.



# Form the Shield Continuity Strap Over the Splice Shoulder on Each Side

- Form the shield continuity strap over the splice shoulder on each side.
- Install and seal per the manufacturer's instructions.

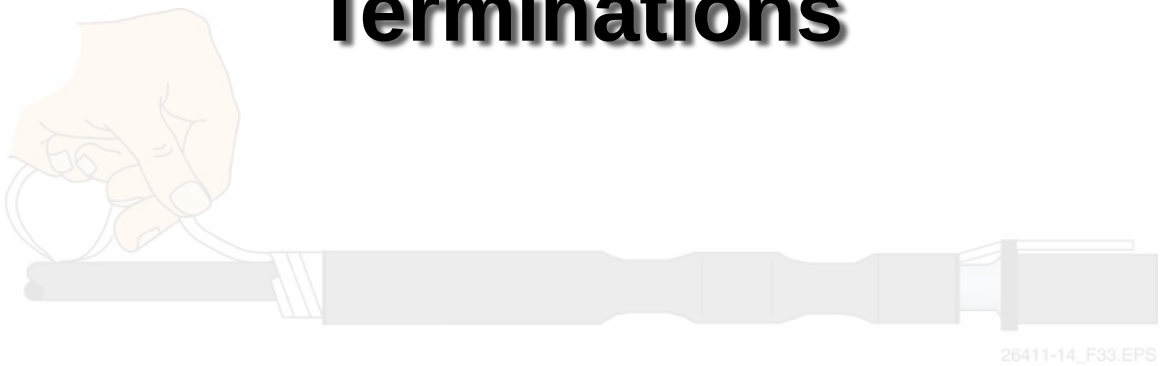


# Next Session…

## Remove Core by Unwinding Counterclockwise

- Position each PST so its leading edge will butt against the splice grounding eye.
- Remove the core by unwinding it counterclockwise and tugging.

## Terminations

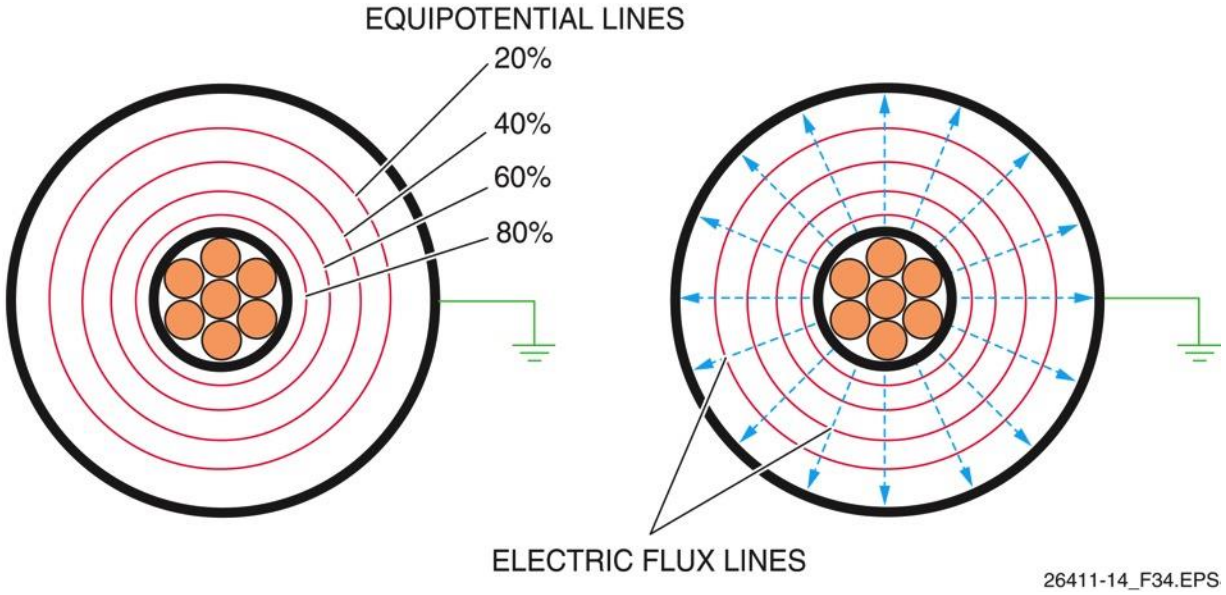



### Performance Task

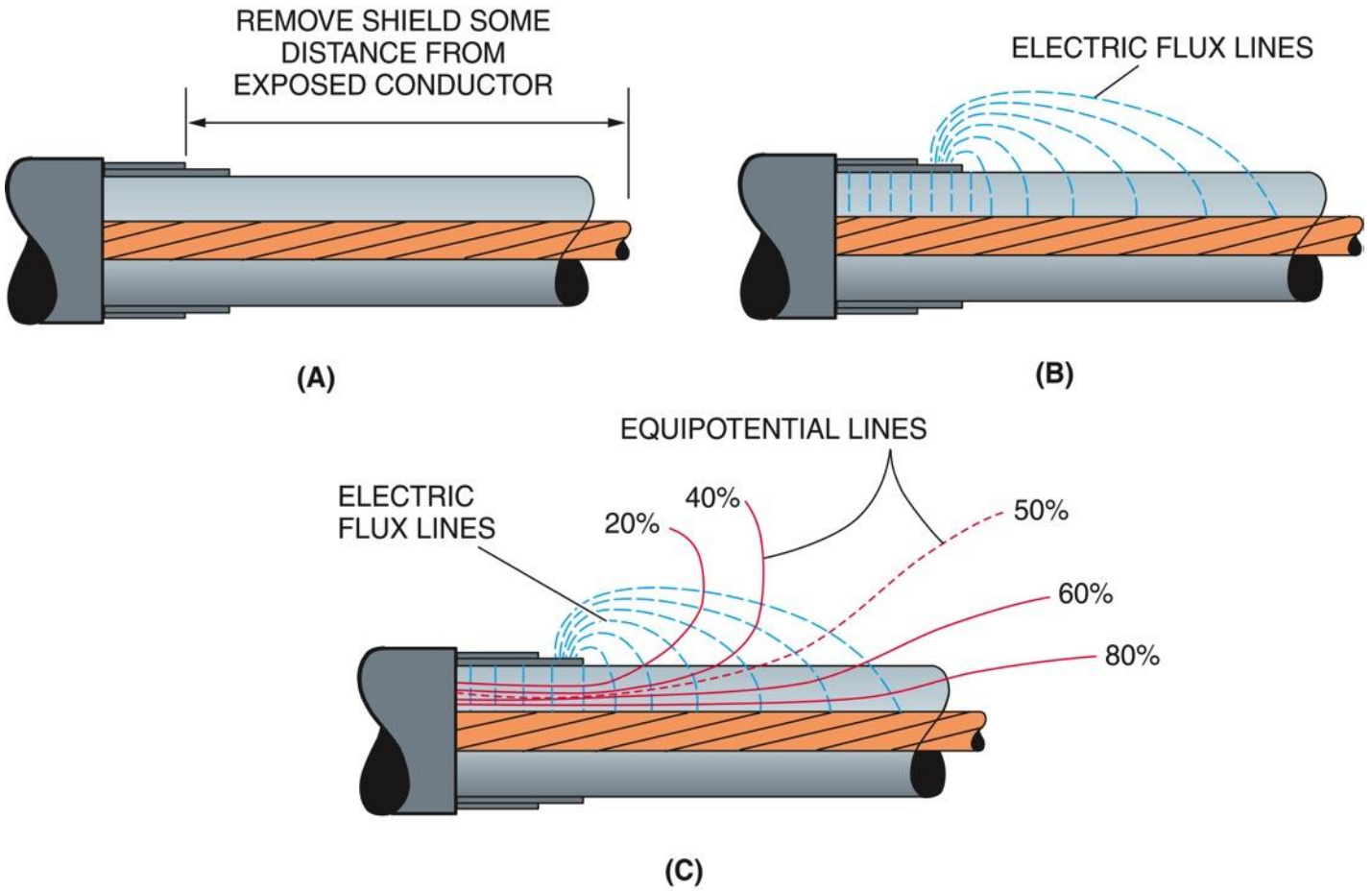
This session will conclude with trainees preparing a cable and completing a splice or stress cone.

# Terminations

- Class 1 terminations provide electric stress control, external leakage insulation between the conductor(s) and ground, and an environmental seal.
- Class 2 terminations provide electric stress control and external leakage insulation between the conductor(s) and ground, but no environmental seal.
- Class 3 terminations only provide electric stress control.

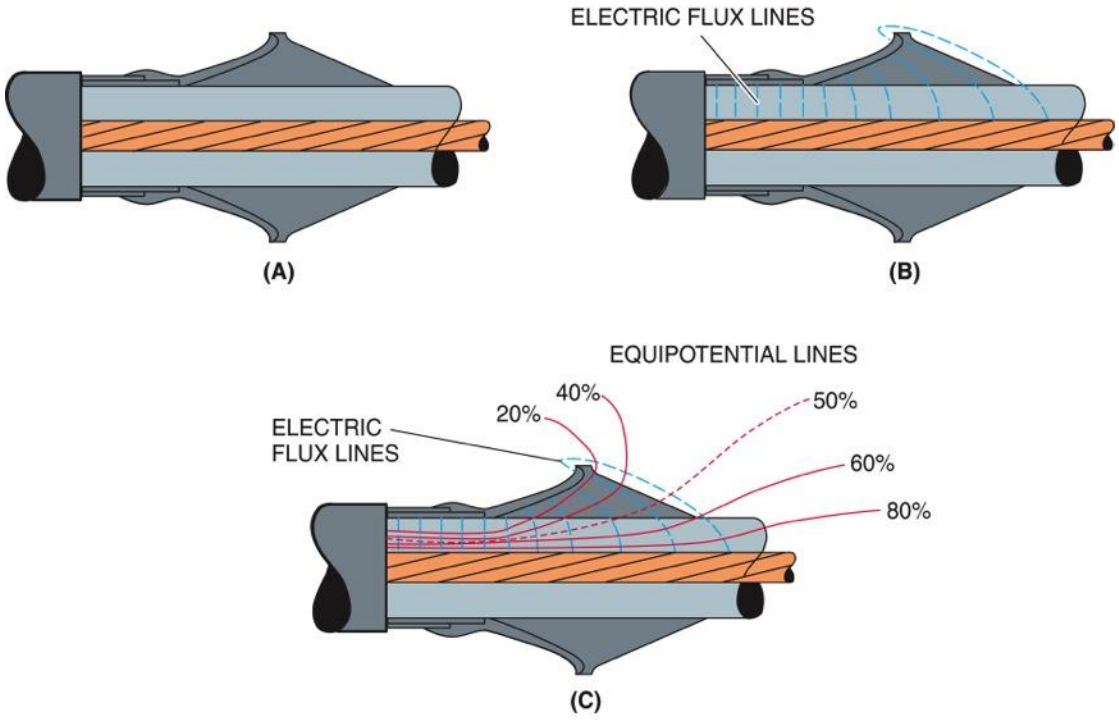


# Removing the Shield



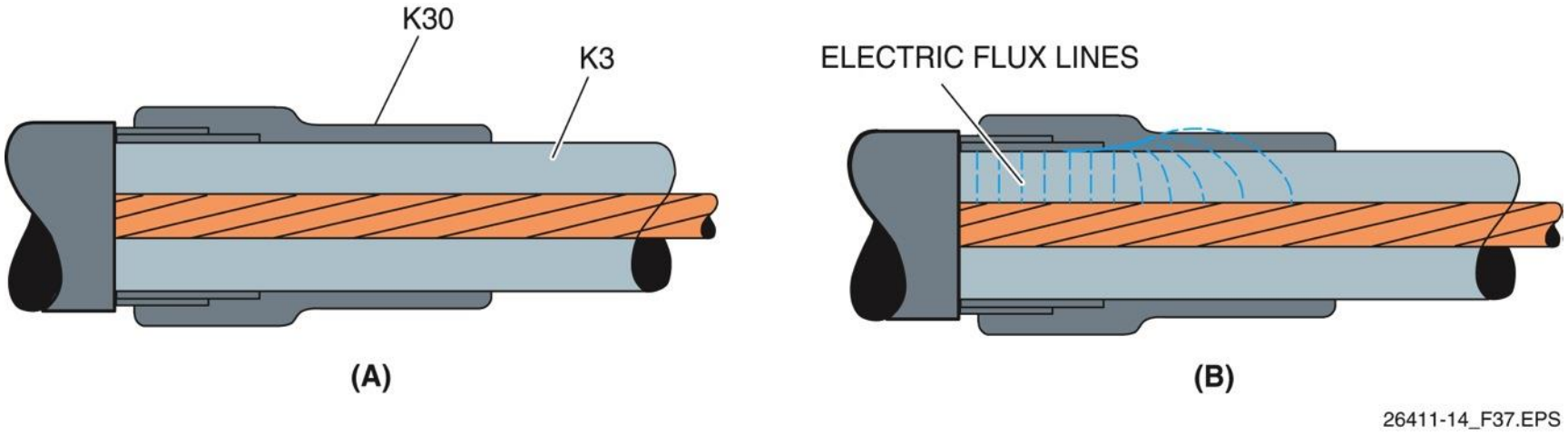
# Geometric Stress Control

Geometric stress control involves an extension of the shielding, expanding the diameter at which the terminating discontinuity occurs and thereby reducing the stress.



# Equalizing Electrical Stresses

With the capacitive method of stress control, the lines of electrical flux are regulated to equalize the electrical stresses along the entire area where the shielding has been removed.

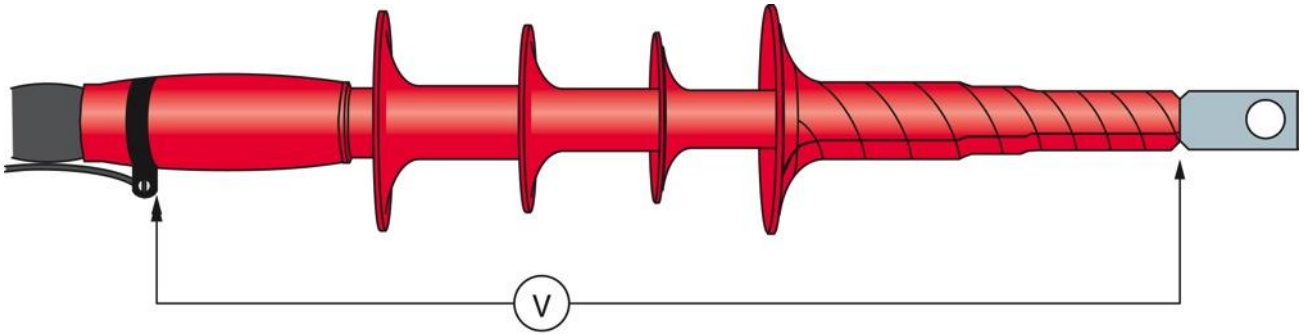


# Insulation Classes and BIL Ratings

| Insulation Class (kV) | BIL (kV crest) |
|---|---|
| 5.0 | 75 |
| 6.7 | 95 |
| 15.0 | 110 |
| 25.0 | 150 |
| 34.5 | 200 |
| 46.0 | 250 |
| 69.0 | 350 |

# A Terminator May Be Considered an Insulator

- A termination can be considered an insulator having a voltage drop between the conductor and the shield.
- The magnitude of the leakage current is inversely proportional to the resistance on the insulation surface.



# Think About It: Disc Assemblies

What is the purpose of the large circular assemblies shown in this picture?

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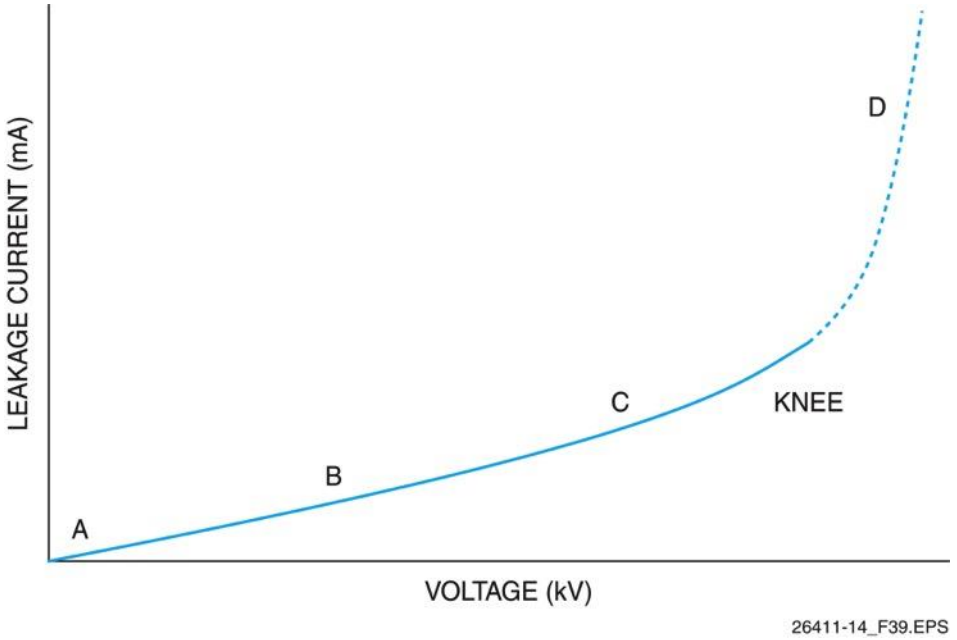
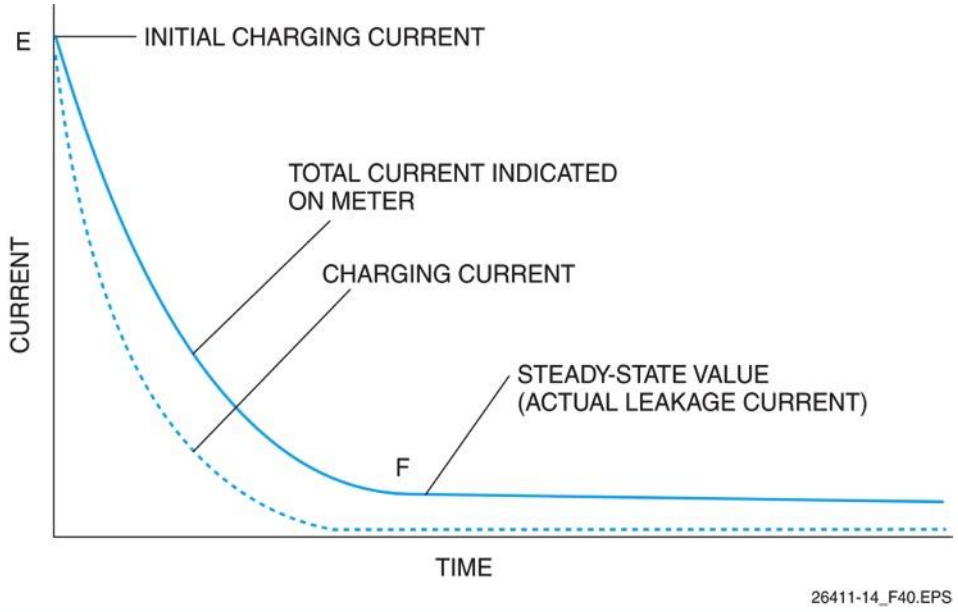
# High-Potential (Hi-Pot) Testing

- High-potential (hi-pot) tests can be used to indicate insulation cracks, voids, or discontinuity; excessive moisture or dirt; and faulty splices or terminations.
- If a leakage current-versus-voltage test depicts the general curve shown here, the tested equipment can be considered satisfactory.



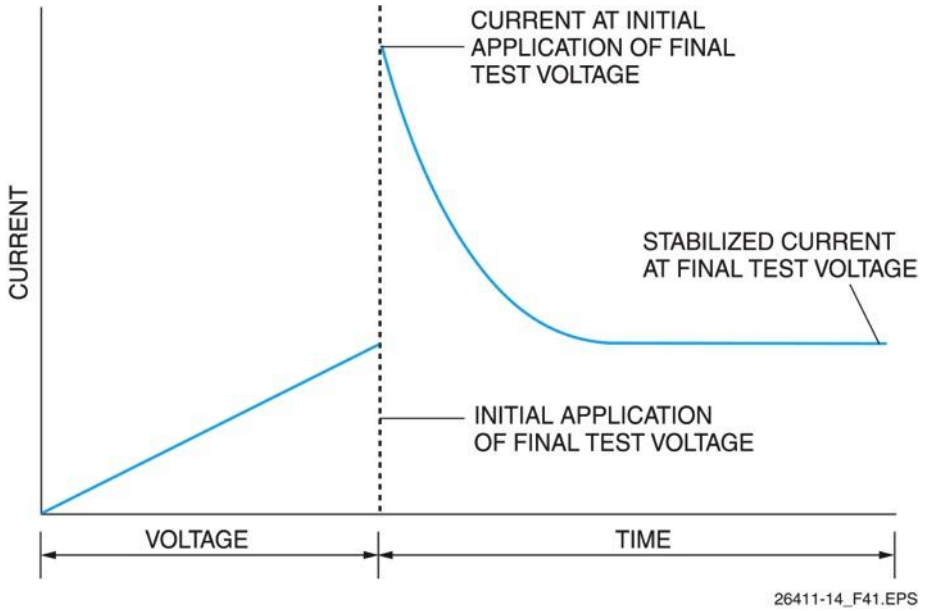
# Current-Versus-Time Curve

- A leakage current-versus-time test may be used on long cable runs or with rotating machinery having a high capacitance between windings or from winding to frame.
- If a leakage current-versus-time test depicts the general curve shown here, the tested equipment can be considered satisfactory.



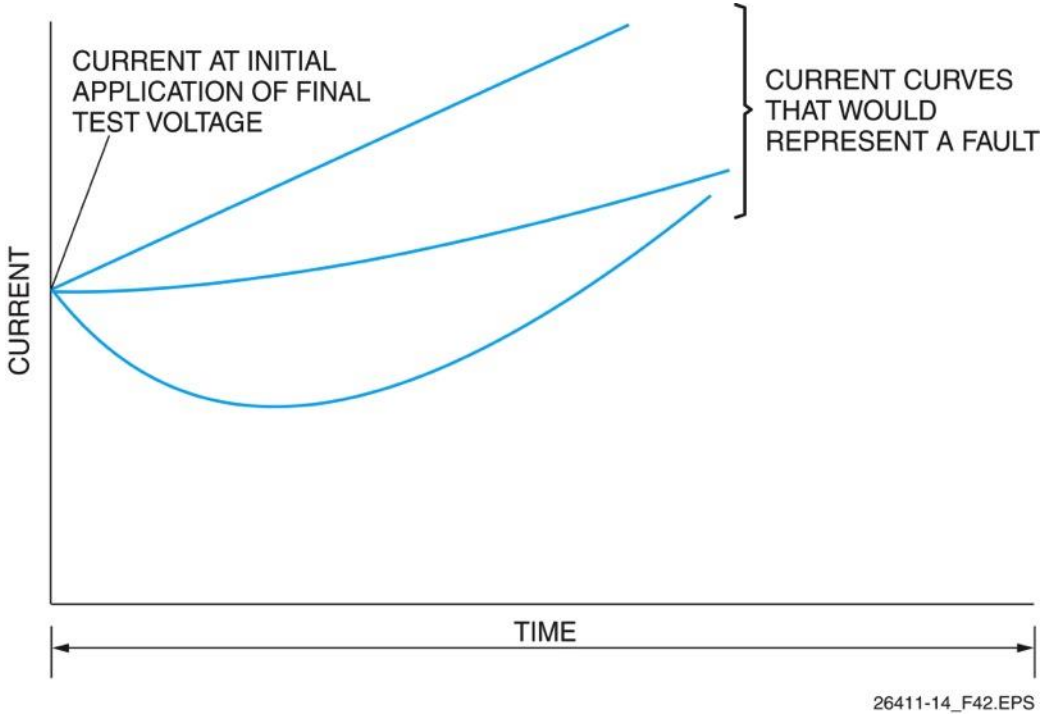
# Current-Versus-Voltage and Current-Versus-Time Curves at Maximum Voltage

- When the final test voltage is reached, the tester is left on and the current-versus-time curve is plotted by recording current at fixed intervals as it decays from the initial charging value to the steady-state leakage value.
- The curve for good cable should show a continuous decrease in leakage current over time.

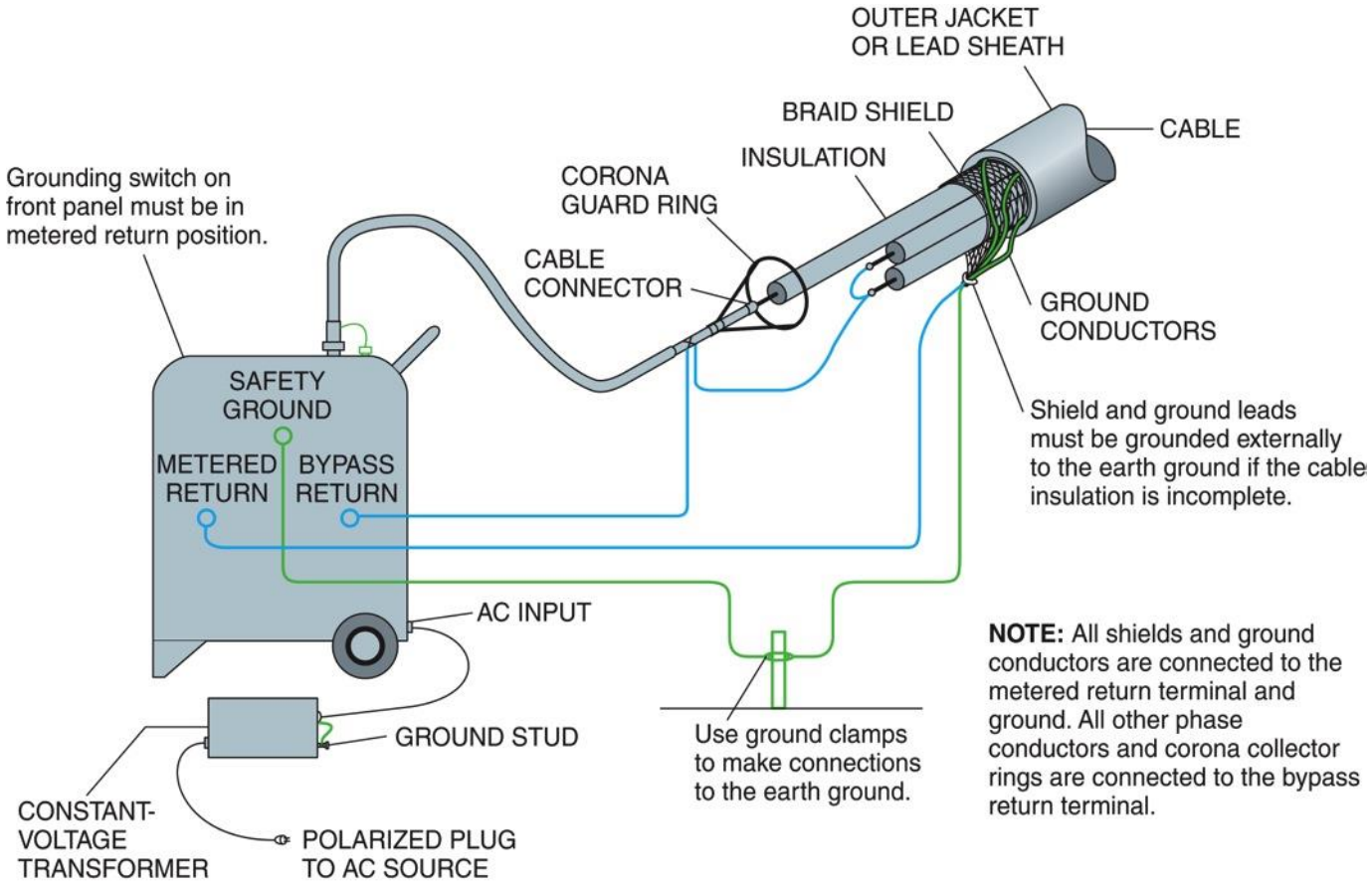


# Faulty Insulation

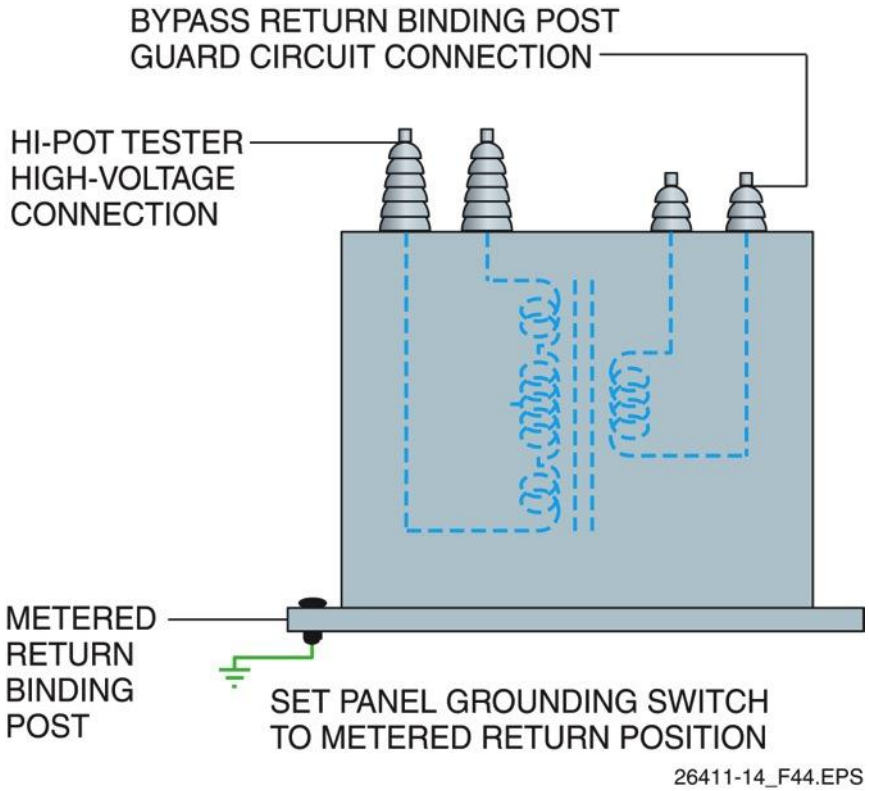
Any increase in current during this test would indicate a bad cable or machine.



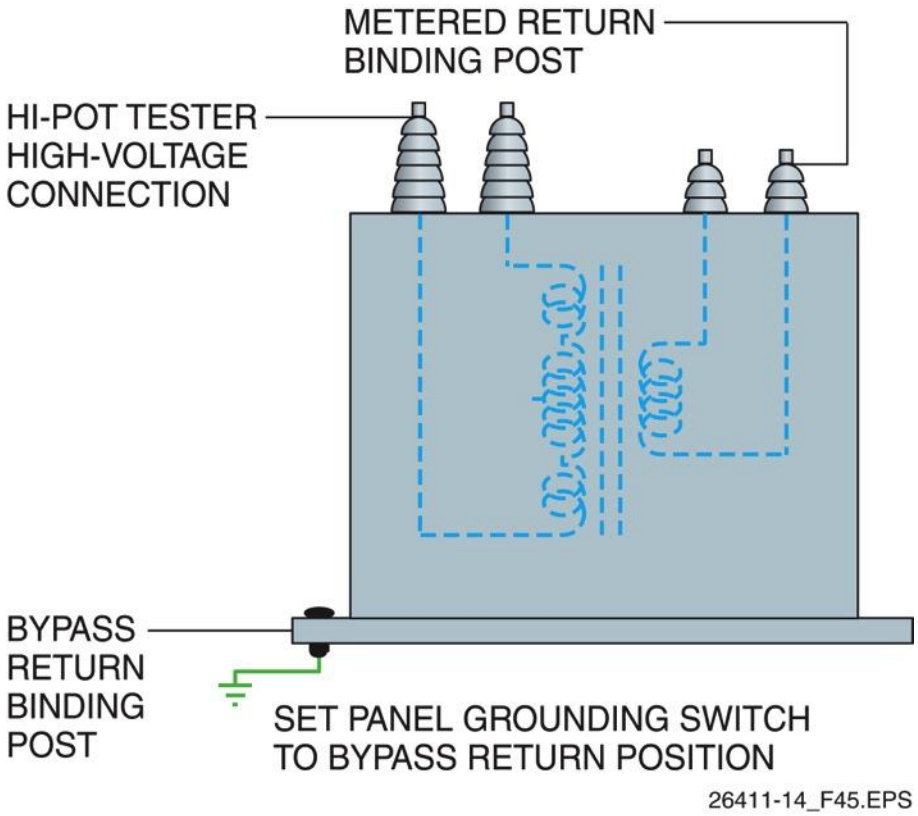
# Hi-Pot Connections for Testing Multiple-Conductor Shielded Cable



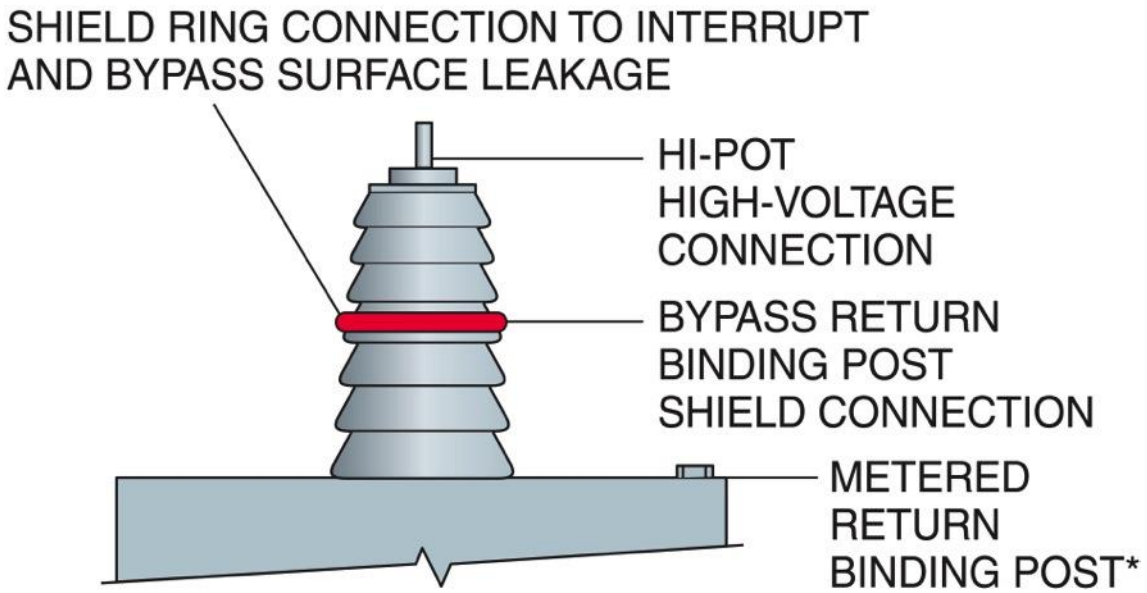
# Testing a High-Voltage Winding to a Grounded Core or Case with a Secondary Winding to a Bypass



# Testing a High-Voltage Winding to a Low-Voltage Winding with the Ground and Case to a Bypass



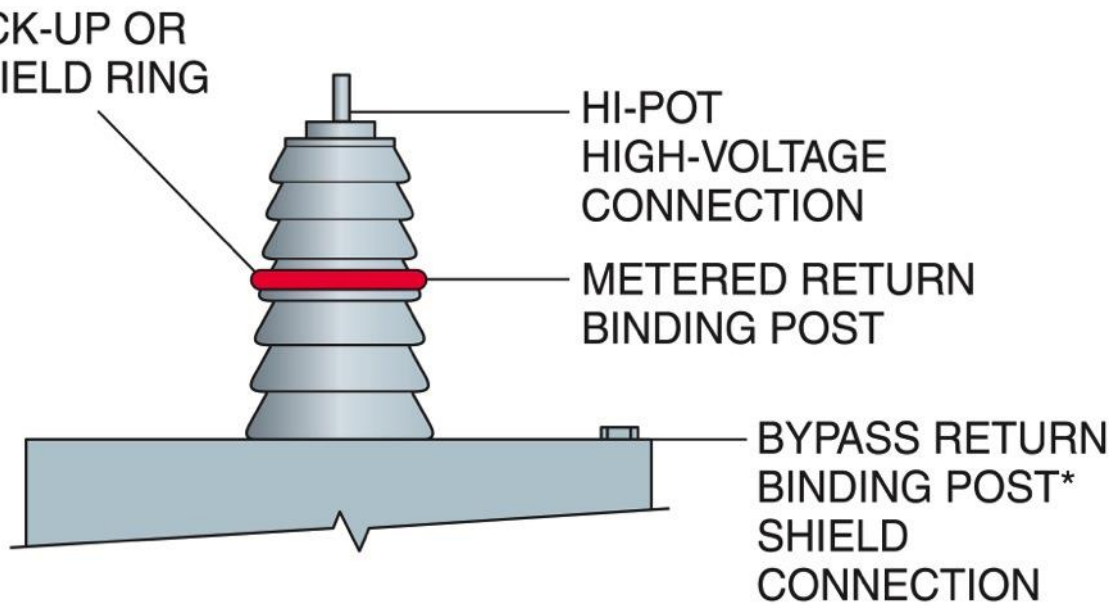
# Measuring Bushing Internal Leakage




*Set panel grounding switch to metered return position

26411-14_F46.EPS

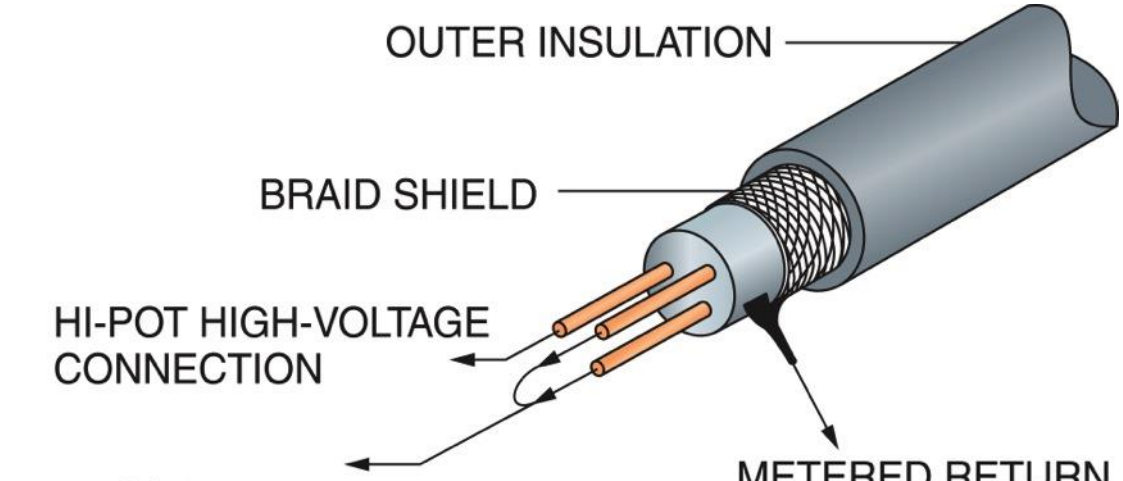
# Measuring Bushing Surface Leakage



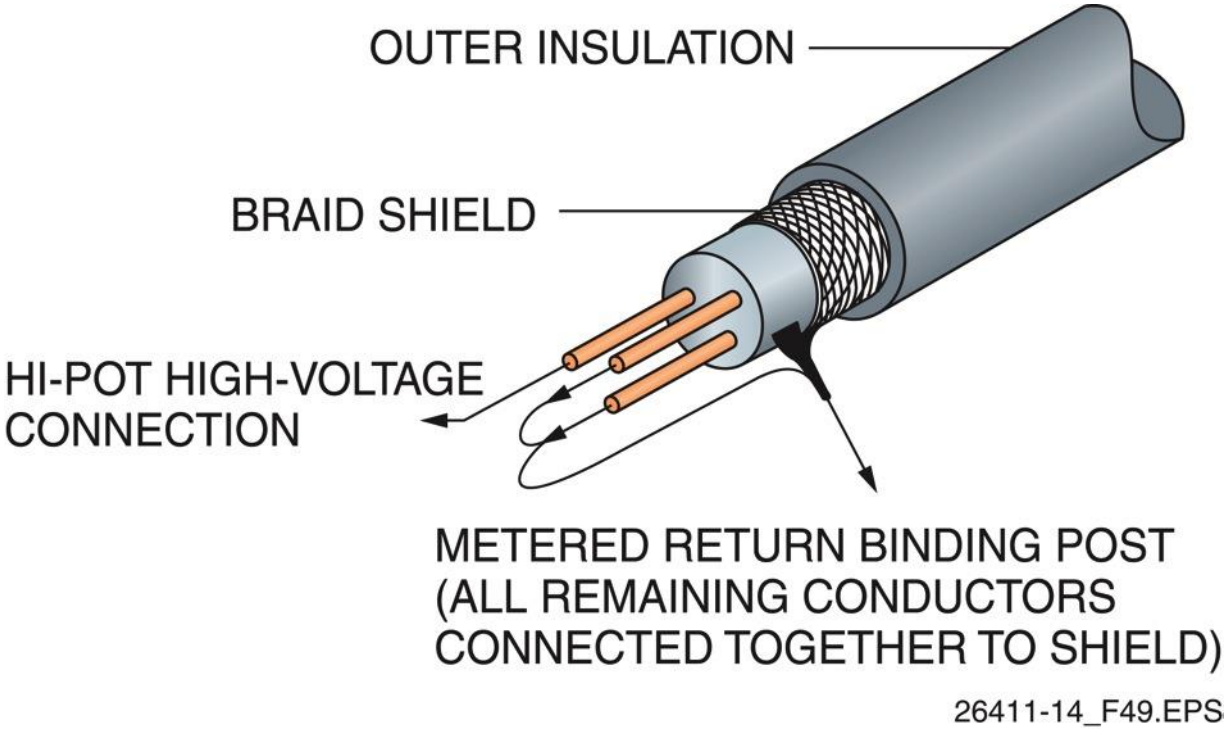

*Set panel grounding switch to bypass return position

26411-14_F47.EPS

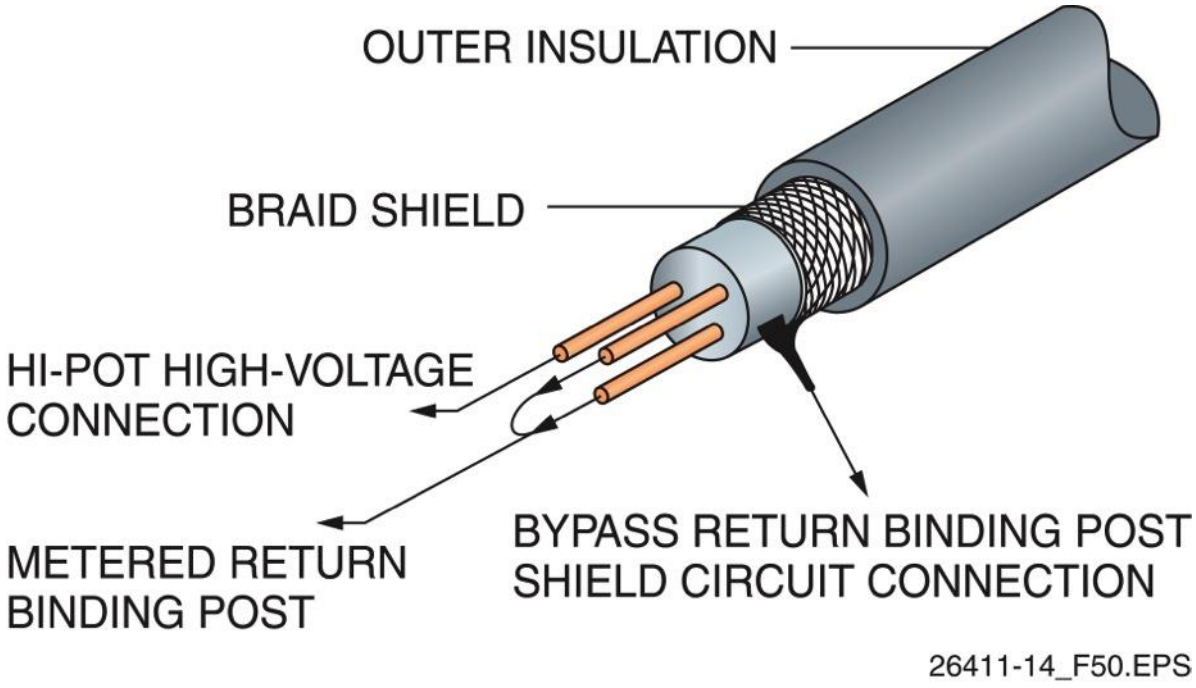
# Testing Cable Insulation Between One Conductor and the Shield



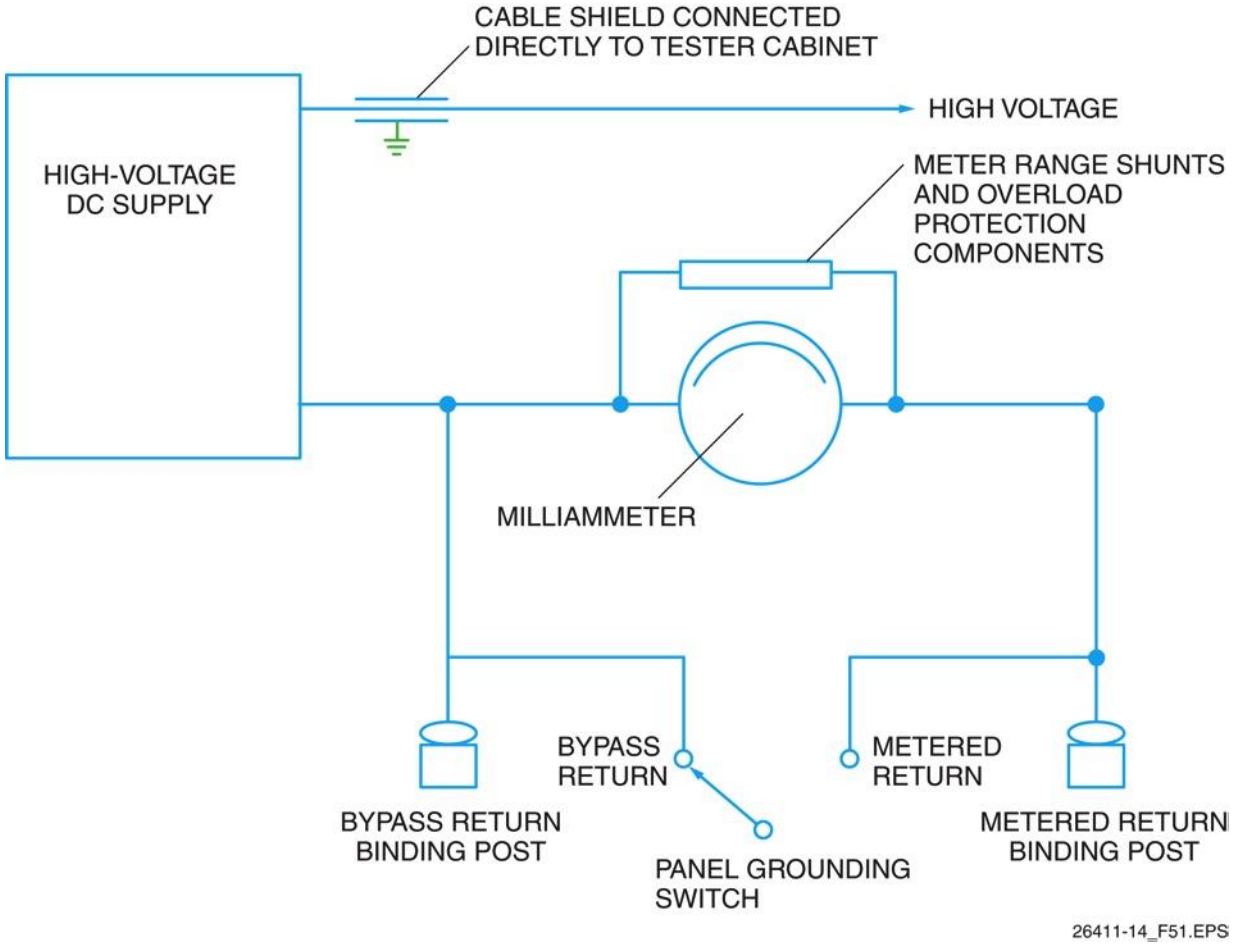
# Testing Cable Insulation Between One Conductor and All Others and the Shield



# Testing Cable Insulation Between Conductors



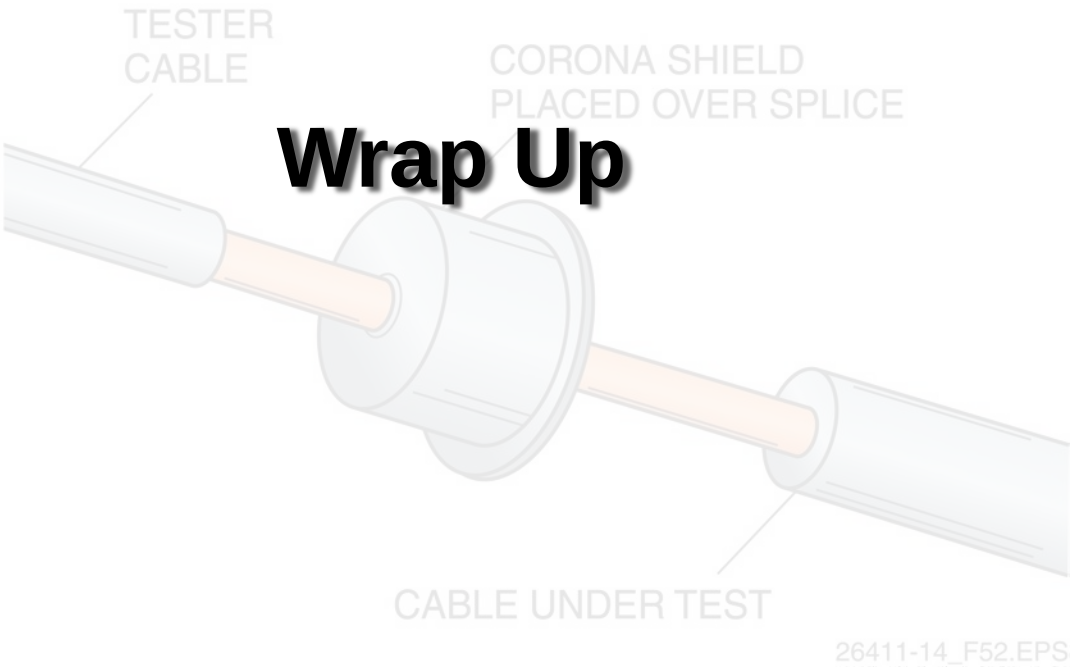
# Simplified Hi-Pot Tester Output Circuit Diagram



# Next Session…

## Corona Shield

A corona guard ring and/or guard shield is used to intercept corona current before it reaches ground.




## Wrap Up

# Wrap Up

3-2-1

3 – Write 3 important things learned during class

2 – Write 2 questions you have about the material

1 – Write 1 thought you had about the material

# Next Session…

## MODULE EXAM

Review the complete module to prepare for the module exam. Complete the Module Review as a study aid.